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THE TALLEST MAMMAL.

By R. Lydekker, B.A.Cantab.

COMPARED with their extinct allies of earlier periods of the earth's history, it may be laid down as a general rule that the large animals of the present day are decidedly inferior in point of size. During the later portion of the Tertiary period, for instance, before the incoming of the glacial epoch, when mammals appear to have attained their maximum development, there lived elephants alongside of which ordinary individuals of the existing species would have looked almost dwarfs, while the cave bear and the cave hyæna attained considerably larger dimensions than their living representatives, and some of the sabre-toothed tigers must have been considerably larger than the biggest African lion or Bengal lion. Again, the remains of red deer, bison, and wild oxen, disinterred from the cavern and other superficial deposits of this country, indicate animals far superior in size to their degenerate descendants of the present day; while some of the extinct pigs from the Siwalik Hills of northern India might be compared in stature to a tapir rather than to an ordinary wild boar. The same story is told by reptiles, the giant tortoise of the Siwalik Hills, in spite of its dimensions having been considerably exaggerated, greatly exceeding in size the largest living giant tortoises of either the Mascarene or the Galapagos Islands. The latter rocks have also yielded the remains of a long-snouted crocodile, allied to the garial of the Ganges, which probably measured from fifty to sixty feet in length, whereas it is very doubtful if any existing member of the order exceeds half the smaller of these dimensions. If, moreover, we took into account totally extinct types, such as the megatheres and mylodons of South America, and contrasted them with their nearest living allies—in this instance the sloths and anteaters—the discrepancy in size would be still more marked, but such a comparison would scarcely be analogous to the above.

To every rule there is, however, an exception, and there are a few groups of living large mammals whose existing members appear never to have been surpassed in size by their fossil relatives. Foremost among these are the whales, which, as we have seen in a previous article, now appear to include the largest members of the order which have ever existed. The so-called white, or square-mouthed, rhinoceros of South Africa seems also to be fully equal in size to any of its extinct ancestors; and the same is certainly true of the giraffe, which may even exceed all its predecessors in this respect. Whether, however, the fossil giraffes, of which more anon, were or were not the equals in height of the largest individuals of the living species, there is no question but that the latter is by far the tallest of all living mammals, and that it was only rivalled in this respect among extinct forms by its aforesaid ancestors. Moreover, if we exclude creatures like some of the gigantic dinosaurian reptiles of the Secondary epoch, which, so to speak, gained an unfair advantage as regards height by sitting up on their hind legs in a kangaroo-like manner, and limit our comparison to such as walk on all four feet in the good old-fashioned way, we shall find that giraffes are not only the tallest mammals, but likewise the tallest of all animals that have ever existed.

In the great majority of animals that have managed to exceed all their kin in height, the increment in stature has been arrived at by lengthening the hind limbs alone, and thus making them the sole or chief support of the body. In some of these cases, as among the living kangaroos and the extinct dinosaurs, the body was raised into a more or less nearly vertical position, and the required height attained without any marked elongation of the neck. In birds, on the other hand, like the ostrich, the body is carried in nearly the same horizontal position as in a quadruped, but both the hind legs and the neck have been elongated. The giraffe, however, has attained its towering stature without any such important departure from the general structure characterizing its nearest allies, and thus preserves all the essential features of an ordinary quadruped. Belonging, as we have had occasion to mention in an earlier article, to the great group of ruminant ungulates, among which it is the sole living representative of a separate family, the giraffe owes its height mainly to the enormous elongation of two of the bones of the legs, coupled with a corresponding lengthening of the vertebræ of the neck. As in all its kindred, the lower segment of each leg of this animal forms a cannon-bone, the nature of which has been explained in the article referred to; and in the fore limb it is the bone below the wrist (commonly termed the knee), and the radius above the latter, which have undergone an elongation so extraordinary as to make them quite unlike, as regards proportion, the corresponding elements in the skeleton of a ruminant, such as an ox, although retaining precisely the same structure. Similarly, in the hinder limb, it is the cannon-bone below the ankle joint or hock, and the tibia or shin-bone above, which have been thus elongated. To anyone unacquainted with their anatomy, it might well appear that a giraffe and a hippopotamus would differ greatly in regard to the number of vertebræ in their necks; but, nevertheless, both conform in this respect to the ordinary mammalian type, possessing only seven of such segments.

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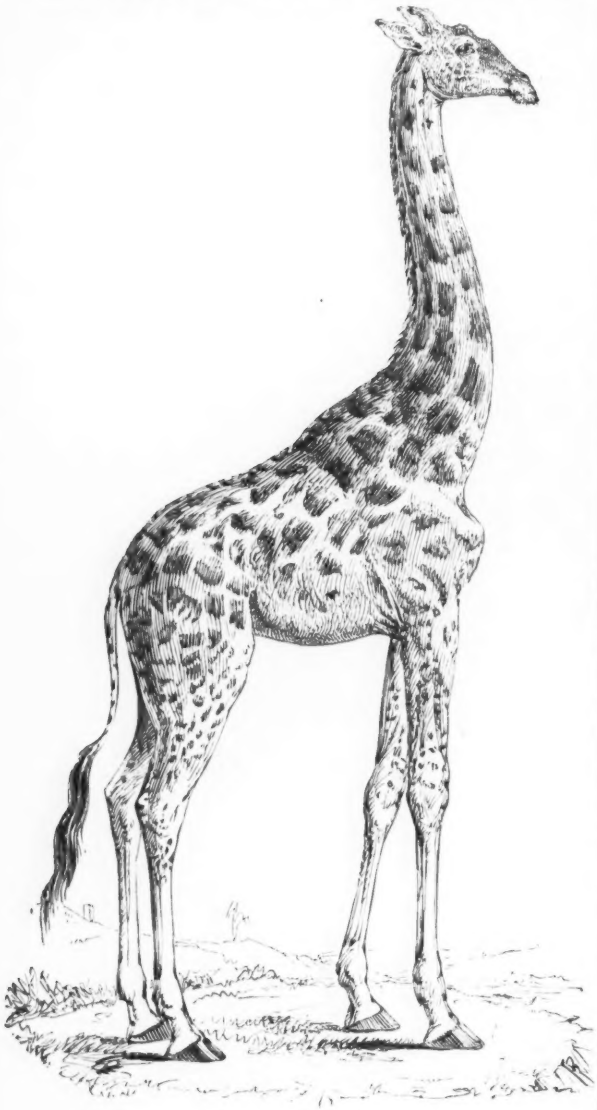
Whereas, however, those of the latter animal are very broad and short, in the giraffe they are extremely long and slender, attaining in full-grown individuals a length of some ten inches. This remarkable adherence to one numerical type in the neck vertebræ is, indeed, a very



The Giraffe.

curious feature among mammals; the extreme contrasts in respect of form being exhibited by those of the Greenland whale, in which each vertebra is shortened to a broad disc-like shape, and the giraffe, where it is equally narrow and elongated.

As regards the height attained by the male of the tallest of quadrupeds, there is, unfortunately, a lack of accurate information, and since it is probable that the majority of those now living are inferior in size to the largest individuals which existed when the species was far more numerous than at present, it is to be feared that this deficiency in our knowledge is not very likely to be remedied. By some writers the height of the male giraffe is given at sixteen feet, and that of the female at fourteen feet, but this is certainly below the reality. For instance, Mr. H. A. Bryden states that a female he shot in southern Africa measured seventeen feet to the summits of the horns; while Sir S. Baker, whose experiences are derived from the north-eastern portion of the continent, asserts that a male will reach as much as nineteen feet, although, most unfortunately, it is not mentioned whether the latter height is merely an estimate, or is based upon actual measurement. From the evidence of a very large, though badly preserved specimen in the Natural History Museum, it may, however, be inferred that fine males certainly reach the imposing height of eighteen feet.

Although this towering stature is the most obvious external feature of the giraffe, it is not one which would of itself justify the naturalist in classing the animal as the representative of a family apart from other ruminants; and we must accordingly inquire on what grounds such separation is made. On the whole, the most distinctive structural peculiarity of the giraffe is to be found in the nature of its horns. These, as mentioned in our article on "Horns and Antlers," are quite unlike those of any other living ruminant, and take the form of a pair of upright bony projections arising from the summit of the head in both sexes, and completely covered during life with skin. In the immature condition separate from the skull, these horns become in the adult firmly attached to the latter; and below them, in the middle of the forehead, is another lower and broader protuberance, sometimes spoken of as a third horn. Obviously, these horns—for want of a better name—are quite unlike the true horns of the oxen and antelopes, or the antlers of the deer; and this essential difference in their structure is alone quite sufficient to justify the reference of the giraffe to a family all by itself. When, however, we come to inquire whether the creature is more nearly akin to the deer or to the hollow-horned ruminants (as the oxen, antelopes, and their allies are termed), we have a task of considerable difficulty. Relying mainly on the structure of its skull, and its low-crowned grinding teeth, which are invested with a peculiar rugose enamel having much the appearance of the skin of the common black slug, some naturalists speak of the giraffe as a greatly modified deer. A certain justification for this view is, indeed, to be found in the circumstance that the liver of the giraffe, like that of the deer, is usually devoid of a gall-bladder. Occasionally, however, that appendage, which is so characteristic of the hollow-horned ruminants, makes its appearance in the giraffe, thus showing that no great importance can be attached to it one way or another. On the other hand, in certain parts of its soft anatomy, the creature under consideration comes very much closer to the antelopes and their kin than to the deer. It would appear, therefore, on the whole, that the giraffe occupies a position midway between the deer on the one hand and the antelopes on the other; while as neither of these three groups can be regarded as the direct descendant of either of the other two, it is clear that we must regard all three as divergent branches from some ancient common stock.

As regards general appearance, the giraffe is too well known to require description, but attention may be directed to a few of its more striking external peculiarities. One remarkable feature is the total lack of the small lateral or spurious hoofs, which are present in the great majority of ruminants, and attain relatively large dimensions in the reindeer and musk-deer. Indeed, the only be taken as an indication of any affinity between the are absent are certain antelopes; but this absence cannot other members of the whole group in which these hoofs

latter and the giraffe, since it is most probably the result of independent development. Equally noticeable are the large size and prominence of the liquid eyes, and the great length of the extensile tongue; the former being obviously designed to give the creature the greatest possible range of vision, while the extensibility of the latter enhances the capability of reaching the foliage of tall trees afforded by the lengthened limbs and neck. In comparison with the slenderness of the neck, the head of the giraffe appears of relatively large size; but this bulk, which is probably necessary to the proper working of the long tongue, is compensated by the extreme lightness and porous structure of the bones of the skull. Lastly, we may note that the long tail, terminating in a large tuft of black hairs, is a feature unlike any of the deer, although recalling certain of the antelopes.

Somewhat stiff and ungainly in its motions—the small number of vertebræ not admitting of the graceful arching of the neck characterizing the swan and ostrich—the giraffe is in all parts of its organization admirably adapted to a life on open plains dotted over with tall trees, upon which it can browse without fear of competition by any other living creature. Its wide range of vision affords it timely warning of the approach of foes; from the effect of sand-storms it is protected by the power of automatically closing its nostrils; while its capacity of existing for months at a time without drinking renders it suited to inhabit waterless districts like the northern part of the great Kalahari desert. And here we may mention in passing that the camel has gained a reputation for being adapted for a desert-life above all its allies which is not altogether deserved. It is true, indeed, that a camel can and does make long desert journeys, but these can only be maintained during such time as the supply of water in its specially constructed stomach holds out, and when this fails there is not an animal that sooner knocks up altogether than the so-called "ship of the desert." Did their bodily conformation and general habits admit of their being so employed, there can indeed be little doubt that the giraffe and some of the larger African antelopes, which are likewise independent of water, would form far more useful and satisfactory beasts of burden for desert travelling than the, to our mind, somewhat over-rated camel. Returning from this digression, it must be mentioned that when we speak of the giraffe being independent of water, we by no means intend to imply that it never drinks. On the contrary, during the summer this ruminant, when opportunity offers, will drink long and frequently; but it is certain that for more than half the year, in many parts of southern Africa at least, it never takes water at all. In certain districts, as in the northern Kalahari, this abstinence is, from the nature of the country, involuntary; but according to Mr. Bryden, the giraffes living in the neighbourhood of the Botletli river—their only source of water—never drink therefrom throughout the spring and winter months. When a giraffe does drink, unless it wades into the stream, it is compelled to straddle its fore legs far apart in order to bring down its lips to the required level, and the same ungainly attitude is perforce assumed on the rare occasions when it grazes.

There is yet one other point to be mentioned in connection with the adaptation of the giraffe to its surroundings before passing on, and this relates to its coloration. When seen within the enclosures of a menagerie—where, by the way, their pallid hue gives but a faint idea of the deep chestnut tinge of the dark blotches on the coat of a wild male—the dappled hide of a giraffe appears conspicuous in the extreme. We are told, however, that among the tall *kameel-dhorn* trees, or giraffe-mimosas, on which they almost exclusively feed, giraffes are the most inconspicuous of all animals; their mottled coats harmonizing so exactly with the weather-beaten stems and with the splashes of light and shade thrown on the ground by the sun shining through the leaves, that at a comparatively short distance even the Bushman or Kaffir is frequently at a total loss to distinguish trees from giraffes, or giraffes from trees.

At the present day, it is hardly necessary to mention, the single species of giraffe is exclusively confined to Africa, not even ranging into Syria, where so many other species of animals otherwise characteristic of that continent are found. This restricted distribution was, however, by no means always characteristic of the genus; for during the Pliocene period extinct species of these beautiful animals roamed over certain parts of southern Europe and Asia. The first of these extinct giraffes was discovered by Falconer and Cautley many years ago in that marvellous mausoleum of fossil animals, the Siwalik Hills of north-eastern India; remains of the same species being subsequently brought to light in the equivalent deposits of Perim Island, in the Gulf of Cambay, and likewise in the Punjab. A second species has also left its remains in the newer Tertiary rocks of Pikermi, near Athens; while those of a third have been disinterred in China. It was, indeed, believed for a long time that France also was once the home of a member of the genus, but the specimen on which the determination was based is now known to be a jaw-bone belonging to the existing species. Although we are, unfortunately, unacquainted with the geology of the greater part of Africa, the foregoing evidence points strongly to the conclusion that giraffes (together with ostriches, hippopotami, and certain peculiar antelopes) are comparatively recent emigrants into that continent from the north-east; but, as we have elsewhere had occasion to mention, the reason why all these animals have totally died out in their ancient homes is still one of the darkest of enigmas.

Unknown in the countries to the north of the Sahara, as well as in the great forest regions of the west, which are unsuitable to its habits, the giraffe at the present day ranges from the north Kalahari and northern Bechuanaland in the south, through such portions of eastern and central Africa as are suited to its mode of life, to the southern Sudan in the north. Unhappily, however, this noble animal is almost daily diminishing in numbers throughout a large area of southern and eastern Africa, and its distributional area as steadily shrinking. Whether it was ever found to the south of the Orange river and in the Cape Colony may be a moot point, although, according to Mr. Bryden, there are traditions that it once occurred there. Apart from this, it is definitely known that about the year 1813 these animals were met with only a little to the north of the last-named river; while as late as 1836 they were still common throughout the Transvaal, and more especially near the junction of the Marico with the Limpopo river. Now their last refuges in these districts are the extreme eastern border of the Transvaal (where only a few remain), and the district lying to the north of Bechuanaland and known as Khama's country, or Bawangwato, together with the northern Kalahari. Even here, however, their existence is threatened, as there is a proposal to put down tube-wells in the waterless Kalahari, which, if successfully accomplished, will open up the one great remaining stronghold of the animal to the merciless hunter. Unless, therefore, efficient and prompt measures are taken for its protection, there is but too much reason to fear that the giraffe will ere long be practically exterminated from this part of Africa;

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although, fortunately, it has a prospect of surviving for many years to come in the Sudan and Kordofan. The great majority of the giraffes killed at the present day in southern Africa are shot solely for the sake of their skins, which are now, owing to the practical extermination of rhinoceroses south of the Zambesi, and the ever-increasing scarcity of the hippopotamus, used in the manufacture of the formidable South African whips known as *jamboks*. The value of a skin usually varies, according to size and quality, from £2 10s. to £4, although they have been known to fetch £5 apiece; and it is for the sake of such paltry sums that one of the noblest and most strange of mammals stands in imminent danger of extermination!

We may conclude this notice by mentioning that although the giraffe was familiar to the Romans of the time of the empire, by whom it was known as the camelopard, it appears to have been almost completely lost sight of in Europe in later times till the closing decades of the eighteenth century, although a single example is stated to have been exhibited alive in Florence some four centuries ago. With that exception, it seems to have been generally regarded as a fabulous animal until one was shot near the Orange River in 1777 by an Englishman, and another by the French naturalist, Le Vaillant, in 1784. From that time onwards our knowledge of the animal and its habits gradually increased, although it was not till the spring of 1836 that four living specimens from the Sudan were brought alive to London, where some of their descendants lived continuously till 1892, since which date the species has been unrepresented in the Regent's Park.

THE MAKING OF MOUNTAIN CHAINS.

By H. G. Wells, B.Sc.

WITHIN the past decade, speculation upon the process of mountain formation has attracted a considerable amount of attention from geologists. With increased stratigraphical knowledge, it has been possible to trace the successive stages in the life of an elevated region with increased certainty, and a great and growing quantity of collateral information has been collected upon volcanic phenomena, earthquakes, the microscopic structure of rocks, and the behaviour of viscous bodies under pressure.

The history of every mountain range seems to resolve itself into the story of an incessant struggle between hypogene and solar energy. From the moment the land emerges from the sea the forces of denudation begin to act upon it; as the upheaving powers win for a time, and the land gradients increase, erosive action becomes more and more efficient, the wedges of the frost come to aid the wear of the rain as the snow-line is approached, and at last the Titanic forces of elevation, the strength of the caryatid giant, old Seismos, becomes exhausted, and the record of his efforts is slowly erased by the at last triumphant forces of the air. This, in brief, is the life-history of every mountain chain, the common plot of all the stories at which we are now to glance.

Somewhere in Swedenborg's writings there is an account of the examination by angels of one of the risen dead. They did not ask the man questions, or subject him to cross-examination. They simply took his body, and methodically from that infallible document read out to him all the things he had done. If I remember rightly, they began by "unrolling his fingers." Whatever act his fingers had performed had left its record in their structure, and whatever thought had passed through his brain had made its infinitesimal difference there. This is precisely the way the scientific man hopes at last to build up the history of the past. Every hill, every pebble, every microscopic patch in a weathered felspar, every cleavage crack in a needle of hornblende, rightly interpreted, bears its witness to the cosmic forces that have been at work upon them; and at present we must read the story of the mountains in this way, so far as our light permits. We may best begin by remarking upon a few of the most significant features of existing mountain masses.

Perhaps, in the order of their importance, one should first notice the fact that almost all our great mountain chains have, high up upon their flanks, rocks of comparatively recent origin, and that we often find great thicknesses of such rocks. The very summit of Mont Blanc, for instance, was once surmounted by Jurassic rocks. Cretaceous rocks crown the Rocky Mountains, and Tertiary masses lie at great elevations upon their sides. Nummulitic limestone, a foraminiferal rock of early Tertiary age, is found at heights of nineteen and twenty thousand feet on the Himalayas, and still younger Pliocene formations lie high on their slopes. The elevated *molasse* of the Alps is a middle Tertiary rock. Not one of the really great mountain chains of the globe appears to have been elevated, or indeed above water, during the Mesozoic period. At that time each was an area of deposition, and further, of subsidence, as the accumulated thickness of Mesozoic strata witnesses. So that we must figure for the beginning of our story a sea, near land indeed, or strata would not accumulate, and with a sinking bottom, or its silting up must have occurred in the place of continuous deposition.

Of course, when we state that the early Tertiary and upper Mesozoic rocks are *recent*, the non-geological reader must understand we mean recent relatively to the length of geological periods. The date of accumulation of these sediments is certainly a matter of hundreds of thousands if not of millions of years.

Mr. Mellard Reade has insisted particularly upon the importance of this fact of the comparatively modern sedimentary structure of mountain masses. He has, indeed, propounded a theory of the origin of mountain elevation largely based upon this. As everybody knows, there is within the earth an enormous store of heat; for instance, near the surface for every fifty feet or so we go down the temperature rises 1°. The temperature of the surface—disregarding solar radiation—is the net result of two processes; heat must be continually arriving from the hotter interior by conduction, and heat must be continually escaping by radiation into space. Mr. Reade asks us to consider the result of a continually increasing thickness of strata over any part of the earth's surface. It will act, just as a blanket does, by preventing the escape of heat. The rocks below will in time grow warmer, since they are no longer superficial, and the growing accumulation of strata will also be heated. The whole mass will expand horizontally and vertically, the movement of subsidence will finally cease, and at last, as a consequence of the lateral strain, the horizontal strata will bulge and be ridged upward into the form of mountain masses.

More striking, perhaps, than the recent age of their constituent strata, and almost equally significant, is the folding that mountainous regions have undergone. We cannot do better than call attention here to the accompanying figure of that classical example, Mont Blanc. The strata the reader will see here have been folded and folded again, and their ridges have been denuded. If one takes the edges of a sufficiently flexible book and approximates the ends, one may imitate these foldings roughly, but they may be imitated still better by compressing layers of cloth laterally beneath a weight.

Now, unless all the elementary presumptions of geology are wrong, these folded strata must originally have been deposited horizontally. Since their deposition, therefore, their extremes have been brought nearer together. This puckering points unmistakably to a squeezing in from the sides. It has been calculated, in the case of the Alps, that

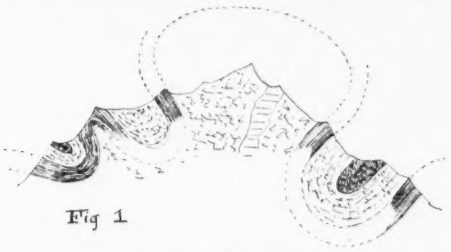
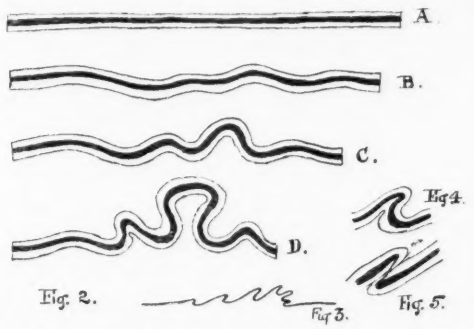


Fig 1

Section of Mont Blanc.

points on either side of this mountain mass have been brought closer to one another by as much as seventy-two miles. In the case of the Appalachian Mountains the estimate is eighty-eight miles. We seem to have here, then, the clear record of the successive stages in such a process as is indicated in a simplified fashion by our Fig. 2 (A, B, C, D), in which A, B and C represent phases in a steady lateral compression, and D repeats C, with some allowance for the action of sub-aerial denudation.

It is upon this aspect of mountain structure that Prof. Lapworth laid particular stress in his memorable address to the Geological Section of the British Association. He insisted upon the horizontal pressure and upon the strata *giving* to this strain at their weakest points, bulging up into ridges and furrows, and with further compression folding over, so that we get at last "over folds" (Fig. 1), with an upthrust or *arch limb*, a *middle portion*, and a downthrust or *trough limb*. The middle portion must especially be under great pressure, and it may undergo crushing, or the fold may rupture and the arch slide forward over the fault to form a reversed fault or over-fault or thrust plane as in Fig. 5. The final result of this folding will be to strengthen the crust at the original weak point by more



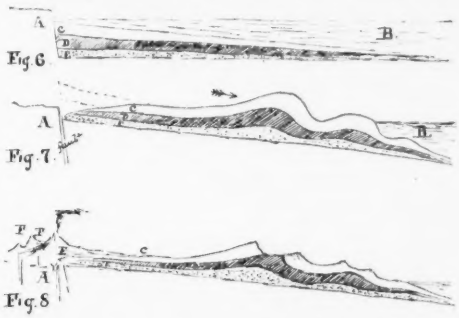
than doubling its thickness, and adjacent portions of the strata will then begin to pucker. So that in the flanks of the original fold fresh folding will arise until we get either a fan-like series (as in Mont Blanc), or a one-sided arrangement (Fig. 3) such as is displayed in the Appalachian and Jura Mountains.

The causes of these mountain foldings may possibly be the lateral stress due to local horizontal expansion, if the theory of Mr. Mellard Reade is correct. But a great number of geologists consider that the prime cause of these foldings, and indeed of mountain upheavals, is the contraction of the earth due to its secular cooling. As this contraction goes on, the cold crust has to accommodate itself to the shrinking interior, and in doing this it is necessarily crumpled and wrinkled. The great land masses and the great oceanic troughs of our earth, moreover, lie along lines of longitude. Winchell has attributed this north and south trend of the chief lines of crumpling to the directive influence of the tidal stress.

Prof. Lapworth, in his address, stated the case for the contraction theory of mountain origin in a remarkably vivid way. He called attention to the manner in which trough and ridge everywhere corresponded. For the upthrust of America, with its Mississippi valley and its unilateral ridges of the Rockies and Appalachians, we have the Atlantic with its division by the Dolphin ridge into two parallel troughs; and corresponding to the broad uprise of the older continents we have the great depression of the Pacific. Coming to the shorter transverse foldings, the Alpine mass had for its trough the Mediterranean; and Central Asia the southward deep of the Indian Ocean. This "undulation" of the surface of the solid earth is far more in agreement with the theory of secular cooling than the theory of Mr. Mellard Reade.

On the other hand, there are those who consider the amount of folding we find in mountain masses, which must amount altogether to a diminution of the earth's circumference by many hundred miles, too great for their conception of the amount of contraction the world has undergone since the rocks in question were solidified. Moreover, in certain localities in Sweden and elsewhere, *crumpled rocks are found lying on an undisturbed base.* Prof. Reyer has recently propounded some novel and remarkably suggestive views in this matter.

He has conducted a series of experiments upon the behaviour of artificial strata made of muddy material or plaster of Paris mixed with glue and variously tinted. These before complete consolidation were placed on boards slightly tilted (5° to 15°), and the arrangement was occasionally tapped to imitate earthquake shocks. There was a general sliding down and crumpling of the mass, such as might conceivably happen in the case of sedimentary rocks, and sections taken after hardening showed, in consequence of this gliding, beautiful imitations of folding, contortion



and faulting such as are seen in mountain chains. Such experiments as this might very easily be repeated by teachers of geology or physiography. They certainly aid the imagination very greatly in thinking out these physiographic problems.

Prof. Reyer's conception of the development of a series of mountain folds, based on experiments of this kind, may be illustrated by the three figures above. While it harmonizes with Mr. Mellard Reade's hypothesis, it seems perhaps a little better adapted to explain complex crumpling of strata than does that supposition. A represents a continental mass, from which the sediments C, D,

E, accumulating in the sea, B, are derived. For manifest reasons, these will be thickest and coarsest near land, where the carrying power of water is at its greatest. Now, on the reasoning already given, this accumulation will finally lead to upheaval, the uprise of strata being greatest in the region where the "blanket" is thickest. That is to say, the base is tilted. The strata consequently glide seaward and pucker up upon the tilted base (Fig. 7). Meanwhile the continental mass (A) is continually undergoing denudation, and the rocks immediately beneath, therefore, are cooling. We may say that the young land to the right is pulling the blanket off its older neighbour, the area A. The cooling of A causes a subsidence and faulting, and the faulting, weakened, and sinking crust is there least able to resist eruptive material, so that at last (Fig. 8) a volcanic chain, F F F, may grow up behind the fold chain.

This, briefly, is the story suggested by Prof. Reyer, a story also fairly consistent with existing mountain structures. But it need not be regarded as a theory absolutely opposed to that so clearly propounded to the English student by Prof. Lapworth. The heating effect of deposition suggested by Mr. Mellard Reade, the crust contraction to which Prof. Lapworth gives prominence, the "gliding" of Prof. Reyer, are all causes that must operate. Prof. Reyer's theory may explain many cases of folding, Mr. Mellard Reade's many cases of upheaval, and yet the great wrinkles on the face of Mother Earth may be due to her withering as the warmth of her youth departs from her.

Clearly, from what has been said, volcanic phenomena are a mere incident in the growth of a mountain chain. They do not, for instance, appear to have played a leading part in Alpine history, and the Rocky Mountains were already elevated before the great trachytic and basaltic outflows of that region occurred. Volcanic forces cannot, therefore, for one moment be regarded as standing in a causative relation to mountain building. Nevertheless, in the Andes and the Himalayas the abundant presence of volcanoes is food for thought. However, the question of the causes of volcanic action scarcely belongs to this paper.

Here we may allude to a third feature of mountain structure. It emphasizes the enormous pressures to which the folded rocks were subjected. It is the alteration of the microscopic structure of these rocks.

We find, for instance, clays, with all their once higgledy-piggledy particles, twisted round into a direction at right angles to the force of compression, so that they can be split up into laminæ, and are no longer clays but slates. Limestones lose the traces of their organic relics, and become recrystallized as marble. Some rocks are seen with their constituent minerals literally crushed and rolled over and into one another, as though they had been through a colossal crushing mill (Mylonitic structure). The quartz of granite, for instance, is powdered, the felspar cracked and reduced to cloudy particles, the mica twisted and shredded. The rock has also been, as it were, *masticated* in the presence of in-soaking water. Old minerals have been dissolved out, fresh ones formed.

In some cases a parallel order of the minerals has been induced. It is as if the rock had become plastic under these stupendous stresses, and that we had here its lines of flow. Nothing could be more eloquent of the irresistible nature of the mountain-making forces. It is interesting, too, to notice how we have thus repeated, in a thin flake of rock that would scarcely weigh a grain, the same story of enormous lateral pressure that we find in considering the stratigraphical structure of an Alpine *massif*.

To summarize our deductions, we have in the history of every great mountain chain the following phases. We can do without any appeal to "old Seismos" now to account for the elevation. A long period of quiet subsidence and deposition of sediment is followed by upheaval. There is a process of lateral compression relieved by a bulging, the formation of a ridge or ridges, with troughs on either side. Probably there are no great paroxysms; the steady squeezing and upward creep goes on day by day, year by year, age by age. Strata are imperceptibly thrown into bends, into loops, the foldings are heaped up one above the other, overfolds are formed. The rising mass slowly becomes a prominent terrestrial feature. Stresses, culminating day by day, are at last relieved by the formation of faults and thrust planes, and as the ruptured strata slip there are earthquakes. Rocks are crushed and metamorphosed, softened, moulded, possibly even liquefied. There may be volcanic outbursts along the axis or upon the margins of the rising area.

The emerging mass becomes subjected to denudation. In the main troughs which will be sinking beside the rising ridge, forming seas or lakes, sediments will accumulate. Presently these areas cease to subside and become involved in a greater movement of elevation, as is shown by the Swiss *molasse* and the Siwalik rocks on the Himalaya flanks. So the vast growth continues. Strata tilted on its rising shoulders slide and are crumpled. Above, the snow and glacier are soon at work—unequal heating by day and frost by night, rain and wind, splinter the metamorphosed upturned rock masses into peak and pinnacle, cirque and precipice. Thus in the course of ages the mountain chain attains its prime, and a brief equilibrium follows.

But the forces of lateral pressure and upheaval are dying away or they have found a weaker area elsewhere. The volcanoes become extinct, the earthquakes less violent and less frequent. Every moment a hundred streams carry away their quota of material suspended or dissolved. So the period of decay sets in. From the still eruptive Himalayas we may turn to the more quiescent Alps, from there again to the worn-down masses of Scandinavia and Scotland, from there to the still more ancient mountain range half buried beneath the strata of Wales and Central England; and so the story ends at last as it began, in sedimentation in the sea.

In conclusion, attention may be called to the rather remarkable fact that in the moon no great meridional mountain ridges, such as one might expect from the analogy of the earth, are to be traced. Neither have the mountains of the moon so distinctly the linear ridge-like arrangement characteristic of terrestrial mountain axes. One might have anticipated, on the contrary, in the absence of an atmosphere and atmospheric denudation and with feebler gravitational attraction, that broad regions of crust folding would have been more conspicuous than on the earth. It may be that these features have been masked by the subsequent precipitation of the lunar atmosphere; but the volcanic character of lunar scenery is hardly consistent with this hypothesis. This, however, is a question for the astronomer to consider.

Letters.

[The Editor does not hold himself responsible for the opinions or statements of correspondents.]

To the Editor of KNOWLEDGE.

DEAR SIR,—The arguments which you have brought to bear upon the significant question, "What is the Sun's

Photosphere?" are of wide import; for if they be valid for the sun, they must be equally so for the great majority of the stars. It seems impossible to stop short at the conclusion that "the light of the solar photosphere is due to the brilliant incandescence of the most refractory substances present in the sun, at a level where they are just on the point of being driven into vapour." The further inference presses itself upon us that "the most refractory substances" in the stars behave similarly; and these substances are likely to be, if not identical, at any rate closely analogous in sun and stars. Hence, if photospheric temperatures be determined by their boiling-points, a very narrow range of diversity can be allowed to stellar emissive power. All stars of normal constitution must radiate a nearly equal amount of light and heat per unit of superficial area. Binaries with known orbits afford, however, a measure of what has been called their "density-brightness." Supposing, in other words, their mean density to be the same, the intrinsic lustre of their photospheres can be determined. It is found to vary enormously; but if the condensation theory of photospheric formation be true, there can be but little difference in this respect between one star and another. If we admit the theory, then, the observed variations must be laid to the score of density, not of brilliancy. This, however, involves somewhat improbable consequences. The whole bulk of the stars of γ Leonis, for instance, should, on the supposition in question, be composed of matter fully seven thousand times more rarefied than the average solar materials; and these stars being of the same spectral type with the sun, no differences of absorption could help to explain away any part of this vast discrepancy. Again, δ Cygni sends us one hundred times more light than we should receive from the sun if it were so situated as to form with a satellite-sun a system with the same period, and of the same apparent dimensions as the system of that binary. The surface of δ Cygni, if of solar brilliancy, should accordingly, in order to enclose an equal quantity of matter with that constituting the sun, be one hundred times more extensive than the solar surface; that is to say, the star must be one thousand times less dense than the sun. If these results be inadmissible, then nothing remains but to revert to photospheric diversities of lustre.

From certain of the Algol-stars, however, a direct measure of brilliancy may in time be derived. Thus, spectroscopic determinations of relative velocities in the system of Y Cygni will give, apart from any hypothesis, the joint mass of its two equal components; their bulk can be inferred from the duration of their phases, once the size of their orbits is known; and should it prove possible to ascertain their distance from the earth, their total light—consequently, their photospheric brilliancy—will follow at once.

Faithfully yours,

AGNES M. CLERKE.

[I do not feel that we can safely assume that all stars are composed of similar materials. The uniform difference in the colour of the larger and smaller components of binary stars seems to point to a difference of composition rather than to a difference in the temperatures of the large and small stars (see *Old and New Astronomy*, p. 784). And the densities of the planets of the solar system seem to point to the conclusion that the different planets must be composed of different materials; otherwise it is difficult to conceive why Mercury, which is smaller than the earth and larger than the moon, and presumably hotter than either of them, should be denser than either the earth or the moon. The earth is about 5·66 times as heavy as water, or about twice as dense as the average density of the rocks which compose its surface—a fact which might be accounted for on the assumption of uniform composition, by assuming that the matter composing the central parts of the earth is materially compressed by the enormous weight of the overlying strata. The moon is about 3·46 times as heavy as water, and though presumably colder than the earth owing to its larger surface compared with its mass, it is conceivable that the moon might be composed of similar materials less closely compressed under the more feeble action of lunar gravity. But Mercury, which has a diameter of about 3000 miles, is about 6·85 times as heavy as a similar sized globe of water—a density which could hardly be accounted for, on the above assumption as to uniform composition, even if it were assumed that Mercury is much colder than the earth.

If we were able to assert that all stars must be composed of similar materials, and that the brightness of their photospheres corresponds to the boiling temperatures of the same substance, there might still be a difference in the apparent brightness of the photospheres of stars, caused by differences of absorption above the photosphere due to differences in the density and mass of the stars, as well as to differences in the explosive energy which carries matter into the regions of the chromosphere and corona above the photosphere. Possibly we are not even warranted in assuming that such differences must give rise to a difference in the type of stellar spectrum emitted.

While generally concurring with Miss Clerke, it seems to me that we cannot safely assume that it is *improbable* that one star is a thousand times as dense as another star—in fact, the evidence afforded by the disposition of the stars on the nebulous streams of the Hercules cluster seems to me to point to the conclusion that these stars are very little denser than the nebulous matter surrounding them, and consequently that their average density is probably less than a thousand millionth of the density of our sun.—A. C. RANYARD.]

EXPLOSIONS IN THE SUN.

To the Editor of KNOWLEDGE.

DEAR SIR,—I have read your most interesting and suggestive article on the solar photosphere in the October number of KNOWLEDGE, and in reference to this will you permit me to draw your attention to a point which I should much like to see discussed in your valuable periodical? I refer to the suppose dexplosive combinations of gases at the solar surface.

It appears to be generally assumed that when two (mixed) gases, having a strong chemical affinity, are cooled from a very high temperature to the point of dissociation, a violent explosion will be the result. Now I understand by the term "explosion" a sudden, almost instantaneous, increase of volume, accompanied (or caused) by a great rise of temperature, the potential energy due to the chemical affinity having been suddenly converted into kinetic molecular energy, or heat. But this can only occur when the molecules of the combining gases are in unstable equilibrium previous to the explosion. Thus when hydrogen is mixed with an equivalent of oxygen at ordinary temperatures the mixture is unstable, and on applying a relatively minute force the gases explode, an enormous amount of heat being evolved, so that the resulting water vapour, which otherwise would only occupy two-thirds the original volume, expands to many times that volume.

But suppose the two mixed gases to be at their dissociation temperature, then the force which we call chemical affinity is exactly balanced by the molecular repulsion due to the extremely high velocity of the molecules, and when this velocity is slightly reduced by cooling, combination

will take place without violence and without producing any heat, for it is obviously paradoxical to suppose the temperature to rise; if it did, dissociation would again take place. Consequently there will be no expansion, but, on the contrary, a contraction, as the compound molecule will require less space than its constituents.

My view, therefore, is that chemical combinations taking place under the solar conditions, namely, the cooling of gaseous mixtures from temperatures above their dissociation points, will simply result in contractions of volume, and I cannot see that these will be of the nature of explosions.

Of course it may be said that explosive combinations might occur when the component gases are not mixed, but cool separately to a temperature considerably below the dissociation point. A subsequent accidental mixing would then, no doubt, set free the energy due to their chemical union. But in this case also true explosion would not occur, as the gases could not be diffused into each other and then ignited as in terrestrial explosions. Under solar conditions ignition would always occur immediately the gases came into contact, and would continue, only in the region of contact, as a surface flame until one or other element was entirely consumed.

When, on the other hand, the combined elements are re-heated in the lower strata of the solar photosphere and re-dissociated, expansions will occur, which possibly, if confined by some means, would be sufficiently violent to account for the observed outbursts. But that these expansions would not necessarily be of a violent character seems probable, if we may compare the dissociation of compounds in the sun with the change in vapour density of certain substances which can be experimented upon in our laboratories. Thus nitric peroxide at low temperatures has a vapour density approximating to the formula N_2O_4, but on heating a change takes place independently of the law of Charles, the double molecule $\binom{NO_2}{NO_2}$ being dissociated into NO_2+NO_2; that is, at a given temperature and pressure (above the dissociation temperature) the vapour will occupy twice the volume it would have done in the former condition. But this expansion is by no means sudden and violent, occurring at the moment the dissociation temperature is reached; for according to the accepted kinetic theory of gases, at any temperature, individual molecules are regarded as moving with widely different velocities, the temperature indicating the mean velocity, and therefore dissociation begins at a far lower temperature than the theoretical dissociation point, and it will not be completed until a much higher temperature has been attained. It follows from this, that as the vapour or gas cannot augment its temperature through the required range instantaneously, the dissociation and consequent expansion will take time, and not therefore be explosive.

A serious objection, however, to the theory of chemical combinations and dissociations in the sun appears to me to be the absence of spectroscopic evidence either of the compounds formed or of the combining elements. Under the conditions I have explained above, one would expect to find in the outrushing gases a mixture of dissociated elements. What we actually do find is a mixture of calcium and hydrogen and helium. Of the last-named element of course nothing is known, but the other two at any rate are both positive elements, and therefore unlikely to form combinations or to possess any strong affinity for each other. It is true that in the comparatively rare metallic eruptions other elements (metals) are present, but these are usually seen at the base of an ascending column of heated gas, and seem to be merely thrown up from below by the violence of the outrushing calcium and hydrogen—these latter elements, with helium, being the only invariable constituents of all classes of prominences.

Thus it appears to me that chemical forces such as we are acquainted with fail to account in a satisfactory manner for these extraordinary explosions and outrushes from the solar photosphere, of which I have on several occasions had the good fortune to be an eye-witness.

J. EVERSHED.

To the Editor of KNOWLEDGE.

DEAR SIR,—The few words with which I concluded my lecture to the British Association at Nottingham were, I need scarcely say, not meant to herald a theory of the sun, and it would be unbecoming on my part to enter into a detailed discussion of solar physics. But, as you wish it, I will just say in respect to Mr. Evershed's letter that in reflecting on the past condition of the earth I never pictured a homogeneous mixture of hydrogen and oxygen developing by cooling into explosive or even flame-like combustion. All the probabilities seem to be against such a distribution of the gases. In a heterogeneous distribution, flames would, on Mr. Evershed's own showing, become possible at a certain temperature. The steam might be dissociated in hotter layers and the gases carried again into heterogeneous circulation, just as steam mixed with an inert gas is partly dissociated on passing through a hot tube. These two points were all I contended for.

As to the other matters raised in Mr. Evershed's letter, I will only say that whilst not presuming to argue in favour of chemical explosions as a source of solar eruptions, I would advise caution to those who argue their impossibility. Such reasoning as that offered by Mr. Evershed would never allow us to admit (apart from our experimental knowledge) of such phenomena as the super-heating or super-cooling of water or steam, or the existence of any false equilibria. Iron changes its molecular condition at a certain temperature. When cooled down from higher temperatures the reverse change, which is attended with evolution of heat, should set in gradually. As a matter of fact it does not—we have the phenomenon of "recalescence"—the iron suddenly glows again. This is Mr. Evershed's paradox realized. False equilibria abound in chemistry; what is called chemical affinity seems with our present knowledge most capricious, and I think he would be a rash man who would deny the possibility of super-cooled chemical systems. There is reason to believe that chemical affinity varies periodically with temperature. Ozone which is formed at ordinary temperatures is destroyed at a moderate heat, and, it appears, formed again at much higher temperatures. Chemical phenomena, in short, cannot be predicted, as has been shown again and again, by *a priori* thermochemical reasoning. This being so, I feel, as I expressed myself at Nottingham, that one must not rashly exclude chemical action as a factor in solar phenomena.

ARTHUR SMITHELLS.

[I agree with Prof. Smithells that Mr. Evershed's *a priori* method of reasoning is dangerous and must not be relied upon for the prediction of phenomena which cannot be verified by experiment. The appearances observable on the sun seem to point to the existence of rapid disturbances very like explosions. I notice that Mr. Evershed, who is a practical observer, speaks of the solar disturbances as *explosions*, a word which implies rapid change of volume, if not chemical action. There are great difficulties in accounting for the rapid motions observed on any other supposition. Our terrestrial winds are produced by differences of temperature causing unequal expansions of

the air. Where the surface of the earth is warmed the air rises, and the winds rush in from all sides. But though it is possible to conceive of unequal heating of the rare gaseous matter in the region just below the photosphere, where the photospheric clouds might be conceived of as shielding certain portions of gas from radiation into space, and in the region just above the photosphere where the clouds may shield certain portions from the radiation of the solar nucleus, it is much more difficult to conceive of such unequal cooling in the region far below the photospheric cloud layer, or of velocities being generated by slight differences of weight sufficient to carry the rising matter far above the level of the solar atmosphere.—A. C. RANYARD.]

THE COMPARISON OF PHOTOGRAPHS.

To the Editor of KNOWLEDGE.

DEAR SIR,—The method proposed by Mr. F. H. Glew in KNOWLEDGE for October also occurred to me some months ago. It may interest him to know that I have put it to a practical test. Mr. Downing kindly sent me from the *Nautical Almanac* office the positions of some asteroids, which would be in a suitable position near the meridian in the month of August. I took a photograph of the region round the planet Arethusa on the 22nd, and the following night took another photograph of the same region. I then took a positive by contact printing off the negative of the 22nd, and superposed it on the negative taken on the 23rd. The black *star images* of the negative then exactly fill up the clear white images in the positive, and the *star images* then completely vanish. The image of the *asteroid*, being in different positions on the two plates, will not blot itself out, and it can then be seen at once on inspection. I have had a frame made to hold the two photographs in superposition, and provided with screws acting on slides, so that the one photograph can be adjusted with the greatest precision over the other. The frame slides into an optical lantern, and the image of the photograph when thrown on a screen can be quickly examined for a planet. Yours very truly,

W. E. WILSON.

Daramona House, Street, Co. Westmeath.
October 9th, 1893.

LUNAR CRATERS SEEN IN RELIEF.

To the Editor of KNOWLEDGE.

DEAR SIR,—I have repeatedly observed that when photographs of lunar craters, like the beautiful ones we have lately had in KNOWLEDGE, are viewed so that the light from a window or lamp shines upon them from the same direction as that of the sunlight when the photographs were taken, the craters appear as craters; but if the photographs be turned round so that the light from a window or a lamp comes from the opposite direction, there is immediately an appearance of false relief and the craters seem to be raised up like mounds. The effect is curious, and seems to show that the same drawing and the same arrangement of light and shade can represent indifferently a hollow or an elevation. What is the explanation? I have seen the same effect in looking at the moon with a telescope; the craters seem suddenly to stand up like mounds.

Alderbury Vicarage, Salisbury. R. S. HUTCHINGS.
Oct. 5th, 1893.

[It is evident that suitable shading, as well as perspective drawing, influences our minds in the compound mental process gone through when we translate a picture drawn in two dimensions into objects existing in three dimensions. A little consideration will show that exactly similar outlines might correspond to a hollow or an elevation—a crater or a hill; but with a side illumination the disposition of light and shade would be reversed in passing from the one to the other. And it would be equally reversed if the objects were illuminated from the other side. Consequently, before we can make up our minds whether a drawing represents a bas-relief or an intaglio, we involuntarily consider from which side the light is falling; and a mistake made as to the direction may cause us to interpret the drawing or photograph of a crater as representing a mound with similar outlines, or *vice versâ*.—A. C. R.]

THE SPECTRA AND MOTIONS OF STARS.

To the Editor of KNOWLEDGE.

SIR,—I had intended making some remarks on the letters of Prof. Kapteyn and Mr. Boraston, which have appeared in your columns, on the subject of the spectra and proper motions of the stars and their distribution in space. I have, however, but little to write, and as I hope the new volume of the Draper Catalogue, dealing with the southern stars, will shortly be available, it seems desirable to wait for further data. Prof. Pickering's paper, recently read at Chicago, is a very suggestive one. It confirms one result which I had derived from an examination of the proper motions of the stars, viz., that stars of the Orion type (B) are not to be regarded as intermediate between the Sirian and Solar stars, but that, on the contrary, the ordinary Sirians (A) are to be regarded as intermediate between the Orion stars and those of the Solar type. He does not, however, place the Capellan stars (F) at the end of the list as the dullest and consequently the nearest to us (on the average) for their magnitude, as I hold them to be; and, considering the brightness of Canopus, as well as its small proper motion and parallax (according to Dr. Gill), it is rather startling to find it referred to this type. Perhaps the reference may turn out to be a mistake, like that of Rigel, which is now referred to the Orion type (B). I find also that Prof. Pickering refers the sun to the Arcturian, not the Capellan type. The Galactic type he regards as A. I am rejoiced to see that he contemplates deducing the apex of the sun's way from a separate examination of stars with different types of spectra. If the Sirians of the type A, or the Galactic stars, form a separate system, the fact will probably be revealed by finding a different apex for the sun's way from that derived from stars with other spectra. But the proper motions of stars of type A, and still more of type B, are usually very small, and their true motions are therefore liable to be overlaid by errors of observation and computation. Determinations based on Solar stars will, at all events, be more reliable for some time to come. Sincerely yours,

Dublin, October 17th. W. H. S. MONCK.

THE TINTS OF THE LUNAR PLAINS.

By A. C. RANYARD.

THE full moon, which appears so silvery white as it shines in the evening sky, reflects, according to Zöllner, only about one-sixth of the light which falls upon it, and when its dazzling brightness is partly quenched by daylight it still appears white, and might easily be mistaken for a small white cloud. But as seen beside a vast ball of snow similarly illuminated by the sun's rays, the moon would appear a dull grey, for fresh-fallen snow reflects only 0·783, or rather more than three-quarters of the light which falls upon it; while the

moon as we see it in the daylight reflects less than one-sixth of the light which falls upon it, for the crescent or gibbous moon which is seen in the daytime is never as white as the full moon, because, except when the moon is opposite to the sun, we, in looking from the earth, see some part of the black shadows thrown by the lunar mountains, and the admixture of dark shadows tends to dull the general whiteness of the lunar surface.

It needs only a very cursory glance at the moon to see that it is not all equally white. The rustic and the child, without any optical aid, see dark patches on its surface, in which they recognize the features of a laughing face, or, with the aid of a little imagination, detect the figure of an old man carrying a bundle of sticks. As seen with an opera glass or telescope, the difference in brightness of different parts of the moon's face becomes much more noticeable. It is immediately recognized that the lunar plains are, as a general rule, much darker than the mountainous regions and high ground, and that the moon's limb or smooth outer edge is whiter than the rest of the lunar disc; but at the moon's limb only mountain-tops are visible, the valleys and low-lying land being hidden by intervening hills. We thus learn that on the moon the mountain-tops are whiter than the low-lying land, and from terrestrial analogies we conclude that this is more probably due to some white substance covering the high ground than to a difference between the tint of the soil of which the lunar plains are composed and the rocks of which the mountains are built.

We may, I think, venture to speak of the lunar mountains as being composed of rock, for many of them have very steep sides; and if they were composed of sand, or any very friable rock, we should not expect to find the lofty precipices which are recognizable in many parts of the moon. See, for example, the north-eastern flank of the lunar Apennines (Fig. 2) and the steep conical hills which rise from the Mare Imbrium, such as Piton to the east of Cassini (Fig. 5), and Pico and the Teneriffe Mountains to the south-east of Plato (Fig. 4).

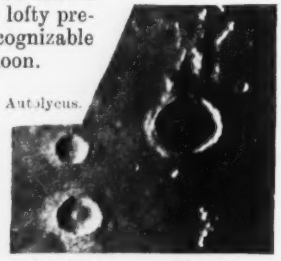


Fig. 1.

On the earth our hard rocks are either of volcanic origin or, if of aqueous or aerial origin, their hardness indicates that they have been buried and have undergone changes due to pressure and heat, or the infiltration of water carrying soluble substances from one particle to another and cementing them together.

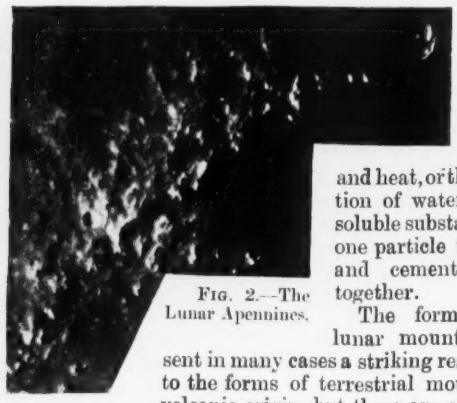


Fig. 2.—The Lunar Apennines.

The forms of the lunar mountains present in many cases a striking resemblance to the forms of terrestrial mountains of volcanic origin, but there are some lunar mountain chains and ridges which seem rather to suggest the crumpling of horizontal strata. See, for example, the Riphæan Mountains (Fig. 3), shown in the photographic plates in the September number, and the ridges to the south of Archimedes, well shown in the plates in this number, as well as the curious stag's horn form, called the Kirch Mountains, to the north of Archimedes and to the east of Aristillus (see Fig. 1).

Fig. 3.
Riphæan Mountains.

But there are no long mountain chains trending north and south upon the moon as on the earth; and if we may accept the theory which attributes the northerly and southerly trend of the chief lines of crumpling of terrestrial strata to the directive influence of the tidal stress, it would follow that the lunar features we now see have come into existence since the epoch when

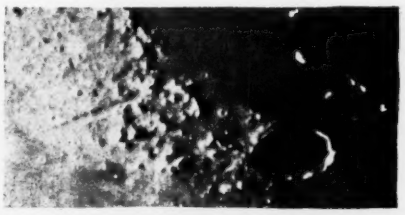
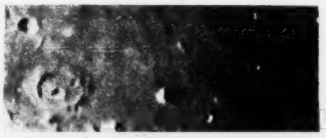


Fig. 4.

the moon's period of rotation about her axis came into coincidence with her period of revolution about the earth; for before that epoch the tide which swept round the moon

Fig. 5.



must have been much larger and more effective in influencing the direction of the ridges of crumpling on the moon than the terrestrial tide now is upon the earth, not only because the earth has more than eighty-one times the mass of the moon, but also because the moon was then probably nearer to the earth than it is at present.

Leaving out of account the great lunar mountain chains which surround the Mare Imbrium, and which seem to be the dilapidated relics of a vast crater ring that once surrounded the plain, it is worthy of

Fig. 6.

Fig. 7.

remark that the small lunar mountain chains and ridges, on the maria above referred to, have a north and south trend. In addition to the Riphæan Mountains, the Kirch Mountains, and the ranges of hills to the south of Archimedes, I would refer the reader to the ridges shown in the

XUM

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SOUTH.

WEST. EAST.

I.—PHOTOGRAPH OF THE NORTH POLE OF THE MOON WHEN 242 HOURS OLD.

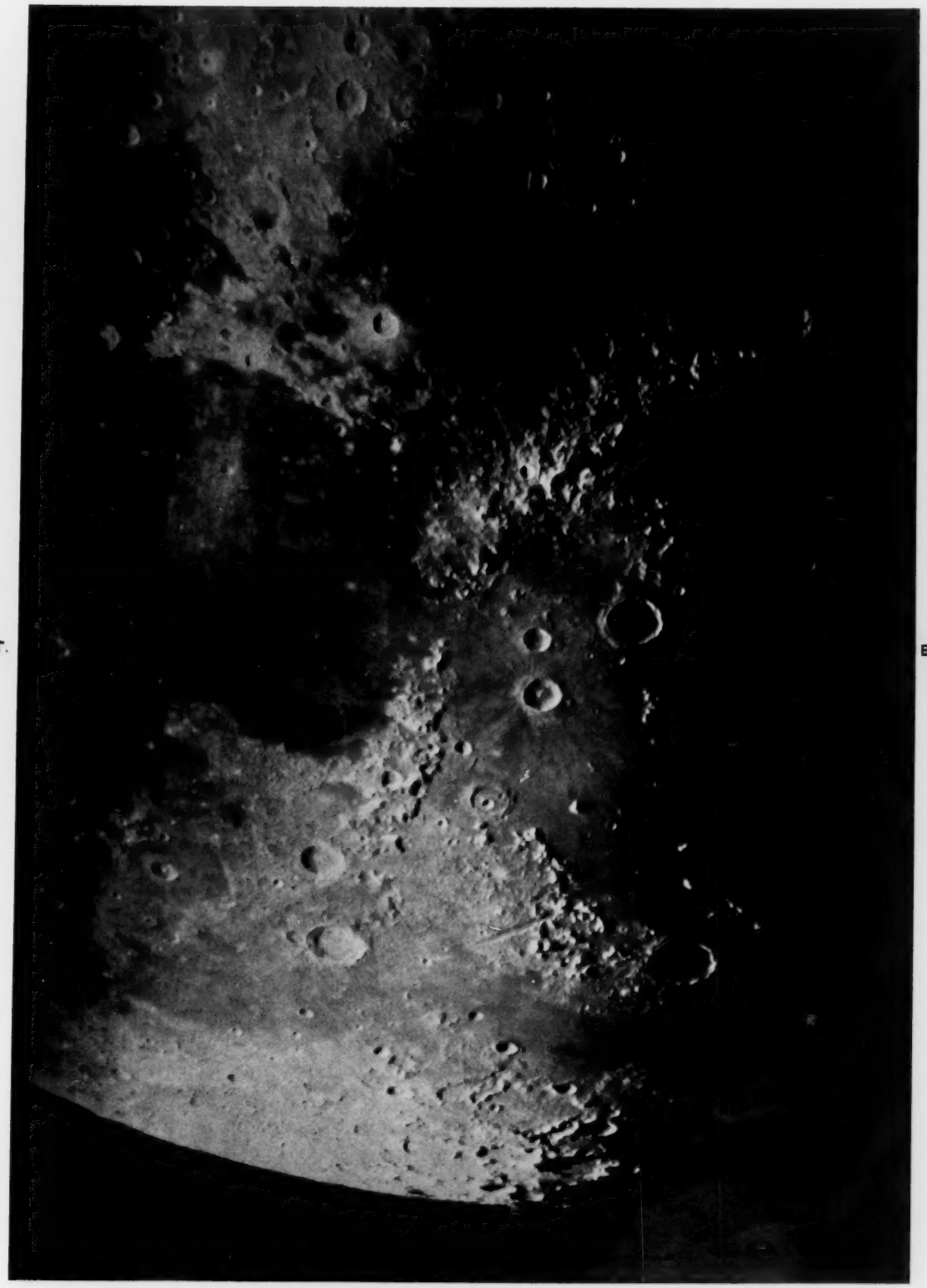
Taken by MM. PAUL and PROSPER HENRY with their 13-inch refractor, at the Paris Observatory, on the 28th May, 1890.
Enlarged 15 diameters from the image in the principal focus.

Direct Photo Engraving Company, 9, Barnsbury Park, N.

XUM

SOUTH.

WEST.



EAST.

II.—PHOTOGRAPH OF THE NORTH POLE OF THE MOON WHEN 216 HOURS OLD.

Taken by MM. PAUL and PROSPER HENRY with their 13-inch refractor, at the Paris Observatory, on the 29th March, 1890.
Enlarged 15 diameters from the image in the principal focus.

Direct Photo Engraving Company, 9, Barnsbury Park, N.

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photograph in the July number, the long ridge on the Mare Tranquillitatis stretching from near Ross (62) to near Sabine (65), and the ridge on the Mare Nectaris stretching northward from Beaumont (322); but it should be remembered that low-lying ridges on maria are more likely to be detected if they have a north and south trend than if they run east and west, because the shadows thrown by them as the sun rises will be more conspicuous if the ridge lies nearly parallel to the *terminator* or division between dawn and darkness upon the moon's surface.

Probably few readers will be inclined to consider that these inconspicuous ridges are the weathered relics of ancient mountain chains, which mark the lines of crumpling of the lunar crust, before the moon commenced to turn the same hemisphere constantly towards the earth. But they are worthy of close study, as they seem to differ

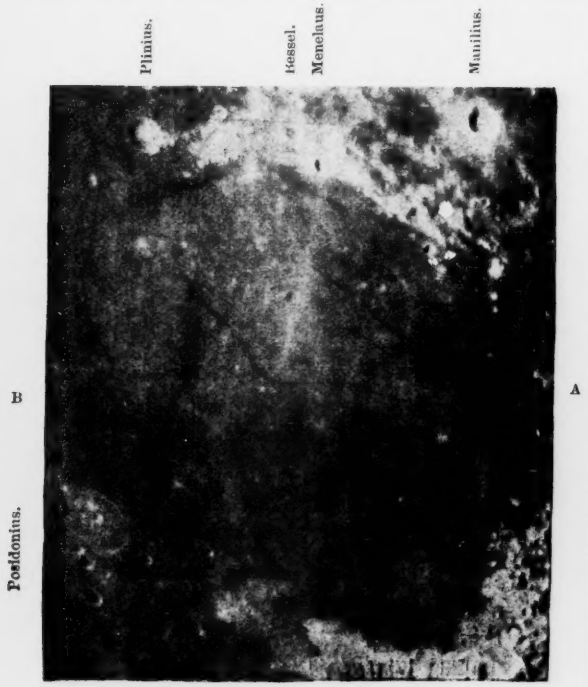


FIG. 8.—The Mare Serenitatis.

in character from the more conspicuous volcanic features to which attention has hitherto been chiefly directed.

If, as seems probable, these mountain ridges were formed at a later period than the plains on which they stand, and if we may safely follow terrestrial analogies, these lunar ridges afford evidence that the moon has sensibly cooled and shrunk since the maria were formed; and they would lead us to conclude that the maria are probably composed of horizontally stratified rocks capable of being pressed or pushed into folds and ridges.

Such horizontal stratification does not necessarily imply the deposition of sediment on an ocean bottom, or water action. Horizontal strata might be composed of volcanic products, such as alternating beds of harder and softer lavas, volcanic mud and scoriæ, but we should expect such beds to be thicker near to the volcanic vents from which they issued, forming a more or less steep or gently inclined cone, with possibly a crater and lake of lava over the throat of the volcano. If we conceive of the Mare Imbrium as representing the solidified surface of such a vast lake of lava, we must be prepared to conceive of the existence of a lunar crater some 600 miles in diameter. But the Mare Nubium and Oceanus Procellarum are still more difficult to account for on such a theory, for they have no surrounding walls, and the one plain merges into the other without any line of demarcation. Volcanic mud might possibly have overflowed such an area, but it is difficult to conceive of a flood of lava hot enough and liquid enough to flow evenly over such an immense region; and in order to account for horizontal stratification we must conceive of more than one ebbing and flowing of the flood, without leaving a trace of a wall around its margin, or an indication of the position of the vent from which the flood issued.

Some may feel inclined to assume that these vast plains correspond to the lunar surface which was formed when the moon first solidified from the liquid state, but the circular form of most of the smaller maria, and the fact that some of them are surrounded or partly surrounded by walls, would lead to the conclusion that these level areas are due to some levelling action which has spread from a centre and levelled surrounding inequalities.

If the lunar rocks are similar to terrestrial rocks and lavas, it seems probable that the original lunar surface would not have solidified in horizontal strata, for, as Prof. G. F. Becker, of the United States Geological Survey, has shown, most lavas and terrestrial rocks expand on melting and contract on solidifying; so that if a crust formed on a liquid ocean of such material it would soon break up by its own weight and sink, bringing other hot material to the surface, which would again solidify and sink, causing a complete mixture until the whole was solidified,* and thus, unless subsequent changes took place by water action or otherwise, the original surface would not be stratified.

The various tints of the lunar plains would lead us to conclude that they are not uniformly composed of the same material, or that some white or dark material has been distributed over their surface in patches. A careful study of the forms of these patches may possibly give us some clue to the action which has been going on. The darker parts of the maria probably correspond in tint to very dark terrestrial rocks, for the moon as a whole reflects less than a quarter (more accurately two-ninths) of the light which would be reflected to us by a sphere of snow. The maria correspond in area to nearly half the area of the visible lunar hemisphere, and the mountainous regions of the moon are not by any means all completely white. So that, assuming the whitest parts of the moon to correspond in their light-reflecting power (or albedo) to snow, the whole mountainous area probably reflects about a third of the light which would be reflected by snow, and the darker parts of the maria would probably reflect considerably less than a tenth of the light which would be

FIG. 9.

* Prof. Becker accounts for the apparently solid character of the material composing the body of the earth by supposing that it is solidified by pressure. Water, which expands on freezing, can by pressure be kept from solidifying, and similarly he concludes that lavas and slags, which expand in melting, can by pressure opposing their expansion be kept in their solid condition though at a temperature above their fusing point when not under pressure.

reflected by an equal area of snow. According to the measurements of Zöllner, clay marl reflects 0·156 of the total light, and dark grey syenite 0·078, or about one-tenth of the light which is reflected by a surface of clean snow. Consequently, we may probably assume that the darkest parts of the maria correspond in tint to very dark lavas.

I would, in the first place, invite the reader's attention to the very curious dark stream which stretches southward from Piton (Fig. 5) on the Mare Imbrium. It is best seen on Plate II., but will be recognized on Plate I., and on both the plates in the December number of KNOWLEDGE for 1890. It stretches up towards the Crater Aristillus (Fig. 1), and branches into two streams about halfway between Piton and Aristillus. Judging from its appearance, it would seem to be a stream of dark material which has flowed from Piton. There can be no doubt about its existence. It is well shown on a photograph taken at the Lick Observatory, now in the Astronomical Society's Library, and on one taken by Dr. Henry Draper, as well as on a photograph taken by Mr. De la Rue.

Another curious dark marking springs from a broad base on the edge of the Mare Imbrium near to Plato, and stretches in a south-westerly direction towards the crater Piazzi Smyth (Fig. 5). This dark marking is best seen on Plate I., but it is also recognizable on Plate II., and on the plates in the December number for 1890, as well as on other photographs. It appears to be connected with other stream-like dark markings more to the eastward, which are traceable on Plate I. and also in the two photographs in the December number for 1890.

I would also invite the reader to study the dark parallel lines on the crater floor of Archimedes (Fig. 1) as shown in the plates, and the curiously contorted dark structure in the region between Archimedes and the lunar Apennines. The darkest part of this structure is near to the foothills of the Apennines. Its curiously contorted form, and especially its darkest portion near to the foothills, is visible in a great many otherwise inferior photographs.

It will be noticed that the upper or southern half of the Mare Serenitatis is brighter than the lower half, and in Plate II. it will be seen that the darker region has a fringe-like border dividing it from the brighter upper half (see A, B, Fig. 8). This might at first be taken for a photographic defect, but certainly some portions of the serrated division may be detected in other photographs. The bright streak which runs through the Mare Serenitatis in a northerly and southerly direction is recognizable in all photographs. It passes through the crater Bessel (Fig. 8), and seems to be a ray from the distant crater Tycho. The dark regions fringing the southern border of the Mare Serenitatis are also striking features—they seem to have sharply defined hard edges; there are also some curious very dark regions to the north of Hyginus (Fig. 9) which are well worthy of study.

Notices of Books.

Popular Astronomy.—We gladly welcome this new astronomical monthly periodical, edited by Prof. W. W. Payne and C. R. Willard, of the Goodsell Observatory, Northfield, Minnesota. The first number contains an excellent selection of short astronomical articles, brightly written in popular language, but nearly all of them containing something that will interest the advanced student of astronomy as well as the beginner. Prof. Daniel Kirkwood gives a most interesting article on "The Asteroids and their relation to the Planetary System," and Prof. Winslow Upton an excellent introductory article on "The Constellations and their History." But perhaps the most interesting of the contents of this first number is an article by Prof. Payne on "Jupiter's Comet Family," illustrated by a diagram showing the orbits of the nineteen members of the Jovian family, from Encke's comet down to Holmes' comet of 1892. The grouping of the aphelia in longitude about the autumnal equinox where Jupiter is moving most quickly through space, because he is then moving in his orbit approximately in the same direction as the sun and his family are moving through space, comes out very strikingly. If subsequent numbers keep up to the standard of the first, "Popular Astronomy" will form a very valuable addition to astronomical literature.

On Hail, by the Hon. Rollo Russell. (Stanford and Company, 1893.) A most valuable and interesting book, which brings together a mass of information with regard to hailstorms and hail. It is illustrated by two full-page photographs of enormous hailstones which fell at Richmond, Yorkshire, after the terrific hailstorm of the 8th July, 1893. It seems that hailstorms have always a cyclonic character. Raindrops, or aggregations of snow, seem to be carried into the central ascending current, which carries them upward, and at the same time the air is rarefied by the centrifugal action of the storm till it is reduced below the freezing temperature. As the frozen snow or drop increases in size, its gravity tends more and more to overcome the rising current, and it is carried upwards with slower and slower velocity, so that smaller drops are carried past it, and when nearly stationary it increases in diameter very rapidly by blending with smaller drops which come in contact with it. Ultimately it is carried out of the central parts of the tornado, and generally falls in the south-east quadrant of the cyclonic storm.

Science Notes.

Natural Science criticizes the language of the American biologist. The disease of speculation is growing in biology, but on this side of the Atlantic, though we may have *idioplasms* and *ids*, things really as unsubstantial as the gnomes who formerly presided over the segregation of minerals, we at any rate have nothing like "bioplastology," "phylonepionic," "parageruntic," and "metaneonic," in which to clothe our ignorance and dazzle the common man. Biology certainly displays a very unhealthy tendency just at present to accumulate theories and theoretical names in the place of recording and systematizing facts.

That familiar friend of the geological beginner, *Eozoon Canadense*, has at last received its *quietus* and must figure nevermore in the category of once living things. Drs. Johnston Lavis and J. W. Gregory have found eozoon to perfection, stolon tubes and everything complete, in ejected blocks of metamorphosed limestone from Monte Somma, and so the last link in the chain of evidence to prove eozoon a merely mineral structure is completed. However, the Archæans were not lifeless, for Dr. Charles Barrois described Archæan Radiolaria as long ago as last year in the *Comptes Rendus*.

A red-hot wire of platinum has for many years past been used for cutting various organic substances, but it is stated in the London *Chemical News* that Mr. Warren has discovered a new use for this method and employs a wire heated by an electric current to saw the hardest kinds of wood. At first the wire would break, but he remedied this by using a steel core platinum-plated by a solution of platinic chloride in ether.

A remarkable increase (1200) in the number of cattle killed by wild beasts in India is noted in the recent report of the Chief Commissioner. This is due, according to Sir Anthony Macdonnel, to the increasing scarcity of deer in the jungle. The native huntsman, in bringing the increasing resources of civilization against the deer, is driving the tiger to trust to domesticated meat, whether he prefers it or not.

Dr. Crochley Clapham, with the help of statistics, would revolutionize our ideas of the "intellectual brow" altogether. The smaller your head, and the more prominent your occiput, the greater your sanity—at least the mad have, as a rule, good heavy frontal lobes. Insane heads, he also showed—and his statistics covered 4000 skulls—have a larger average size than sane.

The question of the systematic abstracting and indexing of scientific papers, to which we called attention in our August issue, is under consideration by a committee of the Royal Society. The need of the index is exemplified in the current issue of the *Philosophical Magazine*, where Lord Kelvin notes too late that his communication upon a piezo-electric pile repeats matter already published by the brothers Curie in the *Comptes Rendus* in 1881. But it will be very difficult to go behind the titles of papers, which frequently do not indicate a tithe of the matters referred to.

A remarkable mass of error, according to Dr. Hurst, has grown out of an incorrect figure of the Berlin specimen of that most ancient of all birds, the *Archæopteryx*. Apparently three claws are shown in the position occupied by the *ala spuria* and *manus* of a bird's wing, but it has not been noticed that the wing feathers could not have been attached to these, but must have been fastened to another digit, corresponding to the huge "ring finger" of a Pterosaur, and which is still buried in the rock upon which the cast lies. Yet, says Dr. Hurst, it is mainly upon this fact that the tracing of the ancestry of birds, not to the Pterosaurs but to the Deinosaurs, rests.

LEXELL'S COMET AND THE QUESTION OF ITS POSSIBLE IDENTITY WITH COMET V, 1889.

By W. T. LYNN, B.A., F.R.A.S.

THE first comet whose return was predicted did not fail to appear about the time at which it was expected. Not so, however, the second, which was discovered by Messier in Paris on the 14th of June, 1770, and calculated by Lexell to be moving in an elliptic orbit of small eccentricity, which it would require only about five and a half years to complete. About a fortnight after its discovery it approached the earth within a distance of only about six or seven times that of the moon, and it was visible for a few weeks to the naked eye. Its position at the return due in the winter of 1775 was calculated to be such that it could not on that occasion be visible; but it was expected that another return would take place in the summer of 1781, and that the comet would then again be conspicuous. This expectation failed of fulfilment, and the erring body was long known by the name of "Lexell's lost comet." Later investigations, however, particularly those of Le Verrier, have fully accounted for the failure, which was caused by the powerful perturbing influence of Jupiter. To that body we owe the comet's visibility in 1770, its orbit having been altered by an approach to the giant planet of our system in 1767. But a much closer approach in 1779 (which brought the comet within a distance from the planet smaller than that of its fourth satellite) must have so changed the orbit again that the comet would not be visible to us at future returns, unless another approach to Jupiter should reverse the effect of this, and bring the wanderer once more within the reach of our vision, telescopic or otherwise. For more than a century at any rate this did not take place; but in 1889, on the 7th of July, Mr. Brooks, of the Smith Observatory, Geneva, New York, discovered a faint comet, which appeared to be revolving round the sun in an elliptic orbit, with a period of about seven years. Dr. Chandler's investigations showed that this body must have made a very near approach to Jupiter in 1886, so much so indeed as to be nearer that body than any of its satellites, excepting, perhaps, the new tiny one discovered by Prof. Barnard in 1892, which is distant from Jupiter's surface by less than the planet's diameter. The probability seemed on several accounts to be great that Brooks's comet of 1889 was identical with Lexell's of 1770, and that Jupiter in 1886 had reversed his work of 1779, and restored to us a sight of the long-lost wanderer. Such a view appeared probable, but it would seem that it must after all be abandoned. Dr. Poor, of the Johns Hopkins University, Baltimore, United States, has made a re-investigation of its motions, availing himself of the principle formulated by M. Tisserand, who succeeded the late Admiral Mouchez as Director of the Paris Observatory last year. This is, that whatever be the nature of the perturbations produced in the elements of the orbit of a comet by the attraction of a planet when the comet passes through the sphere of its activity, one function will remain practically unaltered. It is represented by the formula

$$n = \frac{1}{a} + \frac{2\sqrt{A}}{R^2}\sqrt{p}\cos.i,$$

where n is the function in question, a, p, and i are respectively the semi-axis major, the parameter, and the inclination of the comet's orbit, and A and R are the semi-axis major of the orbit of the disturbing planet, and its radius vector at the point of the comet's closest approach. Now, Dr. Poor has computed the value of n with those elements of Brooks's comet which correspond to the following four points of its path: 1st. March, 1884, the action of Jupiter insensible; 2nd. March 24·5, 1886, entrance into the sphere of activity; 3rd. October 26·5, 1886, exit from that sphere; 4th. September 30, 1889, the action of Jupiter again insensible. These values of n, thus computed, are respectively 0·5289, 0·5242, 0·5233, and 0·5294, showing the very small change produced by so close an approach to the planet as that which occurred in 1886. But the value of n for Lexell's comet amounts to only 0·4852. This seems to render its identity with Brooks's comet of 1889 exceedingly improbable, unless some considerable perturbation had been produced by proximity to another planet besides Jupiter, since the approach to that body in 1779. Saturn is the only other planet which could come into consideration in this respect, and Dr. Poor shows that the nearest approach made by the comet to it took place between 1881 and 1884, and that even then the two bodies did not come within five astronomical units of each other, so that the resulting perturbations were quite inappreciable. With the caution, however, of the true scientific mind, he forbears to express himself decidedly against the conjectured identity of Lexell's and Brooks's comets, but points out that the question may be definitely settled at the expected return of the latter in 1896. Meantime, he promises in another paper (those here referred to, I should remark, are contained in Nos. 302 and 303 of the *Astronomical Journal*) to give the results of an investigation of the path of

Brooks's comet (V., 1889), whilst it was in the immediate vicinity of Jupiter. This will include a discussion of the questions of the probability of the disruption of the comet, and of the possibility that a portion of it was drawn permanently into the Jovian system, becoming a species of satellite of that planet.

DUST AND ATMOSPHERIC PHENOMENA.

By Dr. J. G. McPHERSON, F.R.S.E.

(Lecturer on Meteorology in the University of St. Andrews).

AT a recent meeting of the Royal Society of Edinburgh, Mr. John Aitken read a most interesting and important paper on "Dust and Atmospheric Phenomena." It was a continuation of the investigations made in 1889, which I abridged in these columns in October, 1890. During 1890 he went over the same ground under different atmospheric conditions. He first visited Hyéres, where by his famous instrument he counted 250,000 dust-particles in a cubic inch of the air, whereas on the former visit he counted only 12,000. He observed, however, that where there was least dust the air was very clear, whereas with the maximum of dust there was a very thick haze.

At Mentone, the number of dust-particles in the cubic inch was 13,000 when the wind was blowing from the mountains, but increased to 430,000 when the wind was blowing from the populous town, where the air was more polluted. At Bellagio the result was similar. With the smaller number the air was clear and brilliant, with scarcely any perceptible haze on the hills; but with the larger number there was a thick haze, the distant hills being quite invisible. After a series of observations there, with careful examination of the temperature by wet bulb as well as dry bulb thermometer, he came to the conclusion that the increase in the number of dust-particles accompanied by constant humidity is accompanied by a decrease in transparency; and that the increase in humidity is also accompanied by decrease in transparency if the number of dust-particles remains constant.

When Mr. Aitken first visited the Rigi Kulm, in Switzerland, the air was remarkably clear and brilliant, and the number of dust-particles per cubic inch never exceeded 33,000. On his second visit, in May, 1890, he counted no less than 166,000—about five times the number; this was accompanied by a thick haze, which rendered the lower Alps scarcely visible. The thickness was not due to humidity, for the wet bulb was depressed 10°, therefore the air was very dry; but it was due to the number of dust-particles suspended in the atmosphere. On looking down from the mountain to the valleys, the air was, some time before sunset, so thick that the lower slopes of Pilatus were scarcely to be detected. This was due to a thick haze between the observer and the mountains, as if a veil were hung between him and the distant scenery. The upper limit of the haze was well defined, and though the sky was cloudless, the sun looked like a harvest moon, and required no eagle's eye to keep fixed on it.

Next day there was a violent thunderstorm, which gave an opportunity of making observations at its different stages. At noon, when it was clear, the number of particles to the cubic inch was 66,000. At 6 p.m. the storm commenced, and 60,000 to the inch were registered; but in the middle of the storm he counted only 13,000. There was a heavy fall of hail at this time, and Mr. Aitken accounts for the diminution of dust-particles by the downrush of purer upper air, which displaced the contaminated lower air. For the year before, he observed the same change during a heavy fall of rain on the Eiffel Tower, when the number per cubic inch was as low as 3000.

He next showed, from a reference to the general circulation of the wind over Switzerland during the periods of observation, that when the number of particles was small during his first visit the general air circulation was from the Alps; and, on the second visit, when the number was great, the movement of the air was from the inhabited parts. He also found that on the day of the storm the diminution of the number of particles was concurrent with a change in the direction of circulation, which brought pure air from the Alpine region, and it was when the pure air and the foul air began to mix that the storm broke.

But the most remarkable set of observations was made on the Lake of Lucerne. In the course of an hour there was an exceptional diminution in the number, which made him think that something had gone wrong with his instrument. At 3 p.m he counted 171,000 in a cubic inch, at 3.45 the number was reduced to 28,000. During the interval the thermometer had risen from 71° to 75°, and the wet bulb depression varied from 11° to 19°. On looking about, he found that the direction of the wind had changed, bringing down the purer upper air to the place of observation. The rapid change in the direction of the lower current of air was caused by a south-west wind striking the face of the mountain, which was there nearly vertical. The bending downwards of the trees by the strong wind showed that it was coming from the upper air. At 4 p.m. the thermometer fell to 68°, and the wet bulb depression was 10°; he counted 204,000 particles in the cubic inch—a most remarkable result—but the old conditions were restored by the reversal of the wind.

Returning to Scotland, Mr. Aitken continued his observations at Ben Nevis and at Kingairloch, opposite Appin, Mr. Rankin using the instrument at the top of the mountain. These observations showed in general that on the Ben southerly, south-easterly, and easterly winds were more impregnated with dust-particles, sometimes containing 133,000 per cubic inch. Northerly winds brought pure air. The observations at Kingairloch showed a certain parallelism to those on the summit of the mountain. With a north-westerly wind the particles reached the low number of 300 per cubic inch, the lowest recorded at any low-level station.

The general deductions made by Mr. Aitken from his numerous observations during the two years are that air coming from inhabited districts is always impure; dust is carried by the wind to enormous distances; dust rises to the tops of mountains during the day; with much dust there is much haze; high humidity causes great thickness of the atmosphere if accompanied by a great amount of dust, whereas there is no evidence that humidity alone has any effect in producing thickness; there is generally a high amount of dust with high temperature, and a low amount of dust with low temperature, and a high amount of dust reduces the transparency of the air.

CURIOUS COCOONS.—I.

By E. A. BUTLER.

THOSE insects which, just before assuming their final form, pass into a limbless, inactive condition, or, in other words, become a chrysalis and undergo a complete metamorphosis, evidently need some special protection during this period of rest, when they are unable to look after their own interests. And the need is intensified by the fact that the period of pupa-hood often lasts throughout the winter, so that the insect spends a larger proportion of its life in this helpless and

passive state than in a condition of activity. The means adopted to meet the need are varied, but the majority of cases may be grouped under two heads: either the insect buries itself in the ground, or, remaining above ground, envelopes itself in a silken covering or cocoon. While the former method, from the nature of the case, presents few peculiarities and calls for little remark, the latter is full of interest in consequence of the variety of form and the remarkable adaptations and contrivances which the cocoons exhibit; we therefore propose briefly to discuss the most interesting of these specimens of insect architecture which are to be met with in the woods, fields, and hedges of our own country. We naturally look to the Lepidoptera for our chief, though not for our only, examples; the most notably cocoon-constructing section of this order is the group called Bombyces, including the moths known in popular phraseology as "tigers," "ermines," "eggers," and "emperors."

But before referring to specific instances in detail, a few words are necessary as to the organ by which the material used in these constructions is produced. There is a pair of glands which are found only in the larvæ, and disappear in the adult insect, and in these the silk is secreted as a gummy substance. They are bent and coiled tubes, lying at the sides of the body, and they sometimes extend for a considerable distance from the head towards the tail. Their structure is similar to that of salivary glands, but they do not communicate with the mouth, and consequently the silk does not, as at first sight it appears to do, issue from the mouth. The ducts from the glands unite into a common canal, which opens upon a minute papilla a little below the mouth, and from this the secretion exudes. Though glutinous at first, it has the property of drying and hardening as soon as exposed to the air, thus losing its stickiness. In this, as well as in other respects, it differs from the silk of spiders, which is secreted by glands at the opposite end of the body, and which, as serving the purpose of a snare, remains more or less sticky after exposure.

The cocoons of different species vary in colour from white, through shades of yellow, brown, and grey, to almost black; but this is probably not entirely due to differences in the natural tint of the silk, but to processes it undergoes after having been spun, or to the admixture of foreign matter. The larva always forms its cocoon round itself, so that it is usually an entirely closed covering, with no indication of a way of entrance or exit. As it is most commonly constructed amongst twigs, dead leaves, etc., or in crevices and corners, and under ledges, a few threads are first run promiscuously among surrounding objects to serve as a sort of scaffolding or mooring, and then a much more compact structure is fashioned in the centre of these, so as closely to envelope the body of the spinner.

It is difficult to say what have been the influences that have determined the shape of the cocoon in each species; certainly neither the shape of the caterpillar nor that of the chrysalis is the factor of prime influence, since we find that caterpillars of similar shape make very different cocoons, while there are caterpillars of very dissimilar appearance which make cocoons more or less alike; and there seems no particular reason why a shape that suits one would not equally well suit another. Moreover, it sometimes happens, as with the emperor moth to be presently described, that the small end of the chrysalis lies in the big end of the cocoon, so that no attempt is made to secure what tailors would call a "good fit." The protection afforded by the enclosure of the pupa in a cocoon is not necessarily entirely in the direction of the disappointment of insectivorous enemies—in fact, as to the extent to which this sort of protection may be necessary there is great lack of definite information, and whatever opinion may be formed will be more or less conjectural; we are not in a position to say exactly, from actual observation or experiment, what insectivorous animals would be glad to feed upon these pupæ, but are baulked in their desire by the presence of the cocoon. Besides this somewhat hypothetical advantage, however, there are the obvious benefits of the degree of fixity the cocoon gives to a body which, if lying free and loose on the ground, would be at the mercy of any disturbance in its surroundings, and of the shelter afforded by enclosure in a non-conducting and probably damp-proof medium amidst changing climatic conditions, especially when its use is required during the winter season. But there is abundant scope for inquiry in all these directions, and if any of our readers feel inclined to investigate the subject for themselves, they will doubtless be rewarded with discoveries.

Amongst the numerous cocoons formed by British insects none is more remarkable than that of the emperor moth (*Saturnia carpini*) (Fig. 1). As a rule, cocoons are more or less oval in outline and of similar shape at each end, but in the present instance we have a pear-shaped or flask-shaped body, rounded and swollen at one end, and with a large circular opening at the other. A little distance below the opening a set of stout threads, almost like bristles, pass from the inner wall of the cocoon all round in an upward direction towards the centre of the opening, where they meet, thus closing the cocoon by a hollow, conical, brush-like partition, which effectually bars entrance from without, but admits of easy egress from within by merely pushing the threads on one side. Thus, by this very simple but exquisite contrivance, no obstacle is placed in the way of the exit of the moth when matured, although the precious contents of the chamber are during the long continuance of pupahood securely shut off from any would-be robber in the outer world.

FIG. 1.—Cocoon of Emperor Moth, part of outer wall being removed at the top to show conical barrier of fibres.

The colour of these cocoons is variable; usually they are some shade of deep brown, but sometimes they become of a pale creamy white. It has been supposed by some naturalists that this difference is intentional, and that its object is to enable the cocoon to harmonize more completely with its surroundings, and so more effectually to elude notice. Many careful experiments have been made to determine this point, since if established it would be a more remarkable physiological fact than the change of colour in the surface layers of a caterpillar's skin, under the influence of external colours, to which we alluded some time ago. For we are not here dealing with a case of concealment brought about by the attachment of foreign objects of suitable colour selected from the surroundings, a case which would imply no more than a certain degree of intelligence and ingenuity on the part of the fabricator of the cocoon; nor is it an instance of the colour of the caterpillar itself being so modified as to correspond more closely to its surroundings; but it would be an instance of a living being retaining its own colour unchanged, but possessing the power of modifying the colour of its deep-seated secretions at will, or at any rate in response to external optical stimulus merely, notwithstanding that usually the act of secretion is one of the most unconscious

and involuntary which take place in the life of an organism. The experiments did not lend much support to the hypothesis of protective coloration, but pointed strongly towards a different reason for the presence or absence of the dark brown colour.

By first enclosing single caterpillars which were about to spin in pockets made of various materials, some dark, others light, and, secondly, enclosing families of caterpillars in white and black muslin bags, abundantly supplied within with crumpled pieces of white and brown paper respectively, so as to make the surroundings as uniformly light or dark as possible, Mr. W. Bateson has shown that the colour of the cocoon is independent of that of the material on which it is built, for dark cocoons were attached both to dark and light substances indifferently, and *vice versa*. But it was observed that the more natural were the surroundings of the caterpillar, and the less it was interfered with at the close of its larval career, the greater was the tendency to form a dark cocoon, the light ones being made specially by those which had been removed from their food-plant. Continued association with the food-plant up to the time of transformation thus seemed necessary for the construction of cocoons of full colour. It was further observed that the caterpillars had the power of ejecting from the mouth a green liquid, which, apparently by a process of oxidation, became brown on exposure to the air; and that in all probability a similar fluid was voided from the hinder extremity of the alimentary canal. There were many indications, which we have not space here to detail, that it was this fluid, derived from the partially digested food, and ejected from the alimentary canal, which stained the cocoons and gave them their brown colour, and that when light cocoons were made, the caterpillars had probably already voided this fluid before their isolation, and therefore possessed no further store to stain the cocoon as soon as it should be made; or, by being removed too early from their food, failed to make the fluid, and were therefore unable to give the cocoon the usual layer of colouring. Thus the colour of the cocoon would seem to be dependent, not upon the predominant tint of the surroundings, but upon the condition of the caterpillar at the time it is made.

Of course it still remains an open question why this liquid should be poured out upon the cocoon at all, and in what way it may conduce to the well-being of the insect that its abode during its time of quiescence should be thus varnished. The colouring substance, though soluble in water at first, becomes incapable of being washed out when once the cocoon is stained, thus proving itself a fast colour. It is an obvious suggestion that this dyeing of the cocoon may have something to do with rendering it impervious to the rains of winter; but it is hardly safe to hazard such a conjecture, since other equally plausible suppositions might no doubt be made, which yet experiment might show to be untenable; it is better therefore to wait for the results of further experiments before coming to any definite conclusion. It should be remarked that there seems no particular need of further protection to the chrysalis than that which it already possesses in being enclosed within the very tough skin of the cocoon. Any insectivorous animals which might otherwise feel disposed to prey upon it would apparently be sufficiently kept at bay by this very unmanageable material, so that special efforts for the concealment of the besieged after the acquisition of so excellent a breastwork would seem to be only wasted energy.

The egger moths are so called because of the very compact, egg-like cocoons they make. The two species best known in this country are the oak-egger, a fine large yellowish-brown moth which appears in summer time, and the small egger, a much smaller species of a reddish-brown colour tinged with ashy grey, which makes its *début* in mid-winter. The cocoons of both of these are very similar—parallel sided, and equally rounded at each end (Fig. 2). The silk is close and compact, and forms a parchment-like shell, thin but hard, and extremely smooth within; in each case it is an exceedingly close-fitting cell, which is not more than half the length of the caterpillar that makes it; hence it follows that, as the artificer is accommodated within during the whole of the time of construction, it finds itself very cramped for room as it turns about and carries its thread from side to side. The small egger, in some unaccountable way, always leaves a minute perforation in one side of its cocoon, an arrangement which its larger relative does not imitate. From this hard and compact shell the moth makes its escape by pushing off from one end an irregular piece, which looks as if it had been bitten round. When we remember, however, that the moth is entirely destitute of biting jaws of any kind, the real method of escape is seen to be a great puzzle, for the separation of this portion of the cocoon clearly implies the severance round its edges of the crossing and recrossing threads of which the cocoon is composed, and it is difficult to understand how that should be done without a biting or cutting instrument. Careful watching of the emerging moth is here of little use, for the cocoon is opaque, and the attack is made from within, and when we catch the first glimpse of the head of the newly-fledged insect issuing from the cocoon the deed is already done, and the escaping prisoner has kept its secret as effectually as Messrs. Maskelyne and Cooke in their escape from within their closely-corded box.

Fig. 2.—Cocoon of Oak Egger Moth.

The problem has, however, recently been somewhat satisfactorily attacked in the case of a different insect, and one imprisoned, it might be imagined, more entirely beyond hope of escape than either of the above. The moth in question is the puss moth (*Dicranura vinula*), of whose extraordinary caterpillar we gave our readers a description some time ago (Knowledge, February, 1893). This creature selects a crevice in the bark of a tree, and excavating it into an oval hollow, roofs itself over on a level with the surrounding bark, with a layer of mixed silk and chewed bark, which closely imitates the colour and roughness of the true bark, so that often nothing less than the closest and most minute scrutiny avails for the discovery of the cocoon. This roof of mingled silk and sawdust does not reveal distinct threads, as has been the case with the other cocoons, but seems to be composed of one continuous mass; it becomes so hard and unyielding that the blade of a knife, unless very firmly pressed, slides off and makes no impression on it. This intensely hard roof completely covers in the dumpy brown chrysalis into which the brilliant caterpillar changes, and from this at the end of the following spring issues the large fluffy soft-bodied moth, with its whitish wings prettily pencilled with grey streaks, in a manner which recalls the markings of a tabby cat. In this case, as before, a portion of the hard shell is burst off just above the anterior end of the chrysalis, making a hole just large enough for the moth to squeeze itself out. Thus the problem is repeated, and with an added intensity: how can a soft-bodied creature, with no jaws or claws, work its way through a partition almost as hard as if it had been made of metal?

For the solution of the problem the analytical chemist

had to be appealed to, for the moth, not having sufficiently strong mechanical means to free itself from its prison, invokes the aid of chemistry. Mr. Oswald Latter removed some pupæ from their cocoons shortly before their emergence, and wrapped each up in a piece of the thin blotting paper used by chemists for filtering solutions. Each, therefore, on becoming a moth, had to pierce the paper instead of its cocoon. As this took place, it was found that the paper was wetted at the spot of emergence, a stain being left behind when it dried. By using a number of these stained papers, enough of the material which composed the stains was procured to enable an analysis to be made. It was then found that the liquid, which was evidently poured out by the moth at the time of its emergence, was none other than that very well-known substance, caustic potash, renowned and widely used for its solvent powers. This was a very interesting discovery, for it had not previously been known that any animal secreted a caustic alkali; moreover, it was doubly interesting from the fact, to which we have previously referred, that the caterpillar of the same moth secretes a liquid of a chemically opposite character, viz., formic acid. The next step was to try whether the material of the cocoons was soluble in caustic potash. A few drops were placed on the inside of some cocoons, and in three minutes they were reduced to a pulp. Here, then, stood revealed the means by which the creature was able to effect a breach in its strong prison walls; it actually dissolved its way out by means of a caustic alkali.

But the explanation was not yet quite complete, for if the alkali were the only means of egress used, it seemed likely that there would result a general softening of a part of the wall of the cocoon, and a bursting out through that, rather than, as was really the case, the neat separation of a portion of the wall, the severed piece remaining as hard as the rest. The moth was found to make its exit wearing a sort of cap, consisting of the front part of the chrysalis shell, which fitted on to its head by means of little projections and sockets, and served as a shield, protecting the underlying parts from damage during the passage out. Close examination revealed just beneath this shield a couple of hard sharp points projecting from above the moth's mouth, and usually concealed by the fluffy down around. These are the instruments by which the section is made, though they would be quite powerless if the silk were not first moistened and softened by the secretion. Thus the moth is most wonderfully armed for burrowing its way out; with a shield on its head, two diggers beneath, and a supply of alkali to overcome the resistance of the wall it has to penetrate.

FIG. 3.—Cocoon of Drinker Moth, on grass stem.

When cocoons are attached to grass stems, they naturally tend to become shuttle-shaped; the stem runs up one side, and the ends of the cocoon taper away till they are reduced to the thickness of their support. Two very good instances of this are to be seen in the "drinker" moth and the family of burnet moths. The caterpillar of the "drinker" (*Odonestis potatoria*) is a hairy creature, with two extra long and close tufts of black hairs like horns, one at each end, and also with a number of short snow-white and deep yellow or orange tufts along the sides. It feeds on grasses, and has the habit, when disturbed, of dropping to the ground and rolling into a very compact ring. The moth is coloured something like the oak-egger, but is not so large; nevertheless, the cocoon (Fig. 3) is a good deal larger. It is of a pale yellowish colour, leathery and flexible, and thus quite unlike those we have just been considering. It has a slightly irregular and crumpled appearance outside, but inside is smoother, although the individual silken threads can be much more distinctly traced here than outside, where the texture looks more irregular and matted. Some of the caterpillar's hairs are worked into the structure outside.

The burnet moths are extremely brilliant insects, which frequent grassy hill-sides and meadows, and delight to fly in the brightest sunshine. There are several kinds, but they are all narrow-winged moths, with long stout bodies; the forewings are of a brilliant metallic greenish-black, adorned with crimson spots, and the hind wings are rich crimson with a black border. The commonest species (*Zygæna filipendulæ*) has *six* crimson spots on the fore-wings, and is an abundant and well-known insect in suitable localities. The cocoons of these creatures are of a shining golden colour, thin and papery in consistence, but nevertheless harder and more unyielding than that of the "drinker," as well as much smaller. They are usually attached to grass stems, and three or four are sometimes placed on the same stem (Fig. 4), either one above the other or clustering round at the same level, and therefore more or less overlapping one another. Their bright colour and elevated position makes them very conspicuous objects. Occasionally the cocoons are constructed in other places, such as on fern fronds, thistle stems, or even stones, but the grass stem is the general rule—a rather curious association, since grass is not, as it is with the "drinker," the food-plant.

FIG. 4.—Four Cocoons of Burnet Moth, on grass stem, the empty chrysalis cases projecting.

There is no difficulty in telling whether the insect is within or not, for when it escapes it leaves the front half of the empty chrysalis case sticking out of a hole in the cocoon, and the contrast between the black shell and the golden vase which supports it is very striking. This position is assumed by the chrysalis before the emergence of the moth, whence it is evident that, though limbless, it has the power of climbing; the means of doing this consist of rows of minute hooks on the segments of the abdomen, just as with the leaf-rollers we described on a former occasion. In this habit the burnets are quite unlike the other insects we have referred to, which, as they have no hooks and cannot climb, all leave their empty shell wholly inside the cocoon. Another difference is that the cocoon is simply burst open at the end, and no part of it is actually separated from the rest. But here again we find a resemblance to the "drinker," which does the same; and since in this case the chrysalis skin does not project, and the cocoon is scarcely damaged by the escaping moth, it is not an easy matter, except by the touch, to decide whether the cocoon is empty or full. Neither "drinker" nor burnets require the accommodation of the cocoon for more than a few weeks at the outside, and when once they are broken open and deserted, the weather soon makes them more and more dilapidated, and they are not long in going to ruin.

(To be continued.)

THE FACE OF THE SKY FOR NOVEMBER.

By Herbert Sadler, F.R.A.S.

SOLAR spots show but little diminution in number. Conveniently observable minima of Algol occur at 0h. 4m. A.M. on the 6th, 8h. 53m. P.M. on the 8th, 5h. 42m. P.M. on the 11th, and 9h. 35m. P.M. on the 28th.

Mercury is an evening star during the greater portion of the month in the technical sense of the term, but, owing to his proximity to the Sun and great southern declination, he is very badly placed for observation. On the 1st he sets at 5h. 8m. P.M., 36m. after sunset, with a southern declination of 23° 10′, and an apparent diameter of 6·0″, $\frac{7}{10}$ths of the disc being illuminated. On the 12th he sets at 4h. 57m. P.M., 41m. after sunset, with a southern declination of 24° 43′, and an apparent diameter of $7\frac{1}{2}$″, $\frac{44}{100}$ths of the disc being illuminated. He is at his greatest eastern elongation (23°) on the 5th, and in inferior conjunction with the Sun on the 26th. After this he becomes a morning star, rising on the last day of the month at 6h. 58m. A.M., 46m. before sunrise, with a southern declination of 18° 2′, and an apparent diameter of $8\frac{1}{4}$″. During the month the planet describes a looped path in Libra and Scorpio.

Venus is an evening star, but, owing to her great southern declination, is also very badly placed for observation. She sets on the 1st at 6h. 24m. P.M., or 1h. 52m. after the Sun, with a southern declination of 25° 55′, and an apparent diameter of $17\frac{3}{4}$″, $\frac{65}{100}$ths of the disc being illuminated, and her theoretical brightness being about one half of what it will be at the beginning of January, 1894. On the 16th she sets at 6h. 38m. P.M., or 2h. 28m. after the Sun, with a southern declination of 25° 56′, and an apparent diameter of 20″, $\frac{6}{10}$ths of the disc being illuminated. On the 30th she sets at 7h. 5m. P.M., or 3h. 11m. after the Sun, with a southern declination of 23° 44′, and an apparent diameter of $23\frac{1}{4}$″, $\frac{53}{100}$ths of the disc being illuminated, and the theoretical brightness of the planet being about two-thirds of what it will be at the beginning of next January. During October Venus describes a direct path through the whole of Sagittarius on to the confines of Capricornus, being near λ Sagittarii on the evening of the 11th, σ Sagittarii on the 18th, and the wide pair, h^1 h^2, on the 25th.

Mars is, for the purposes of the amateur, invisible.

Jupiter is now a magnificent object in the evening sky, being visible all night long. He rises on the 1st at 5h. 16m. P.M., or three-quarters of an hour after sunset, with a northern declination of 18° 45′, and an apparent equatorial diameter of 47·9″. On the 16th he rises at 4h. 10m. P.M., or about sunset, with a northern declination of 18° 20′, and an apparent equatorial diameter of 48·4″. He is in opposition to the Sun on the 18th, at a distance from the earth of just 374 millions of miles. On the 30th he rises at 3h. 10m. P.M., with a northern declination of 17° 55′, and an apparent equatorial diameter of 48·0″. During the month he describes a retrograde path in Taurus, to the south-west of the Pleiades. At about 7h. P.M. on the 29th a $9\frac{1}{2}$ magnitude star will be at about 20″ distance from the planet's northern limb. The following phenomena of the satellites occur while the planet is more than 8° above and the Sun 8° below the horizon:—On the 1st an occultation reappearance of the first satellite at 7h. 28m. P.M. On the 3rd an eclipse reappearance of the third satellite at 6h. 46m. 21s. P.M.; an occultation disappearance of the same satellite at 6h. 52m. P.M., and its occultation reappearance at 8h. 4m. P.M. On the 4th an eclipse disappearance of the second satellite at 3h. 33m. 8s. A.M. On the 5th an eclipse disappearance of the first satellite at 5h. 50m. 12s. A.M.; a transit ingress of the shadow of the second satellite at 9h. 50m. P.M., and of the satellite itself at 10h. 31m. P.M. On the 6th a transit egress of the shadow of the second satellite at 0h. 10m. A.M., and of the satellite itself at 0h. 46m. A.M.; a transit ingress of the first satellite at 3h. 7m. A.M.; a transit ingress of the satellite at 3h. 27m. A.M.; a transit egress of the shadow at 5h. 19m. A.M., and of the satellite at 5h. 38m. A.M. On the 7th an eclipse disappearance of the first satellite at 0h. 18m. 57s. A.M., and its reappearance from occultation at 2h. 46m. A.M.; an occultation reappearance of the second satellite at 7h. 48m. P.M.; a transit ingress of the shadow of the first satellite at 9h. 35m. P.M.; of the satellite at 9h. 52m. P.M.; a transit egress of the shadow at 11h. 47m. P.M. On the 8th a transit egress of the first satellite at 0h. 3m. A.M., an eclipse disappearance of the same satellite at 6h. 47m. 36s. P.M., and an occultation reappearance of the satellite at 9h. 12m. P.M. On the 9th a transit egress of the shadow of the first satellite at 6h. 16m. P.M., and of the satellite itself at 6h. 29m. P.M. On the 10th an eclipse disappearance of the third satellite at 9h. 9m. 30s. P.M.; an occultation reappearance of the same satellite at 11h. 21m. P.M. On the 11th an eclipse disappearance of the first satellite at 6h. 8m. 10s. A.M. On the 13th a transit ingress of the shadow of the second satellite at 0h. 27m. A.M.; of the satellite itself at 0h. 47m. A.M.; a transit egress of the shadow of the second satellite at 2h. 48m. A.M.; of the satellite itself at 3h. 2m. A.M.; a transit ingress of the shadow of the first satellite at 5h. 1m. A.M., and of the satellite itself nine minutes later. On the 14th an eclipse disappearance of the first satellite at 2h. 13m. 47s. A.M.; an occultation reappearance of the satellite at 4h. 30m. A.M.; an eclipse disappearance of the second satellite at 7h. 25m. 42s. P.M.; its reappearance from occultation at 9h. 52m. P.M.; a transit ingress of the shadow of the first satellite at 11h. 30m. P.M., and of the satellite itself at 11h. 36m. P.M. On the 15th a transit egress of the shadow of the first satellite at 1h. 42m. A.M.; of the satellite itself five minutes later; an eclipse disappearance of the first satellite at 8h. 42m. 29s. P.M., and its reappearance from occultation at 10h. 56m. P.M. On the 16th a transit ingress of the shadow of the first satellite at 5h. 58m. P.M.; of the satellite at 6h. 2m. P.M.; a transit egress of the shadow at 8h. 11m. P.M., and of the satellite at 8h. 13m. P.M. On the 18th an eclipse disappearance of the third satellite at 1h. 10m. 30s. A.M., and its reappearance at 2h. 43m. 21s. P.M. On the 20th a transit ingress of the second satellite at 3h. 2m. A.M.; of its shadow at 3h. 5m. A.M.; a transit egress of the satellite at 5h. 17m. A.M., and of its shadow at 5h. 25m. A.M. On the 21st an occultation disappearance of the first satellite at 4h. 3m. A.M., and its eclipse reappearance at 6h. 16m. 49s. A.M.; a transit egress of the shadow of the third satellite at 5h. 3m. P.M.; an occultation disappearance of the second satellite at 9h. 49m. P.M. On the 22nd an eclipse reappearance of the second satellite at 0h. 14m. 47s. A.M.; a transit ingress of the first satellite at 1h. 19m. A.M.; of its shadow at 1h. 24m. P.M.; a transit egress of the first satellite at 3h. 30m. A.M., and of its shadow at 3h. 37m. A.M.; an occultation disappearance of the first satellite at 10h. 29m. P.M. On the 23rd an eclipse reappearance of the first satellite at 0h. 45m. 32s. A.M.; a transit egress of the third satellite at 6h. 25m. P.M.; of its shadow at 6h. 44m. P.M.; a transit ingress of the first satellite at 7h. 45m. P.M.; of its shadow at 7h. 53m. P.M.; a transit egress of the first satellite at 9h. 56m. P.M., and of its shadow at 10h. 5m. P.M. On the 24th an occultation disappearance of the first satellite at

4h. 55m. P.M., and its eclipse reappearance at 7h. 14m. 22s. P.M. On the 25th an occultation disappearance of the third satellite at 4h. 34m. P.M. On the 27th a transit ingress of the second satellite at 5h. 17m. A.M., and of its shadow at 5h. 42m. A.M. On the 28th a transit ingress of the third satellite at 6h. 23m. P.M.; of its shadow at 7h. 16m. P.M.; a transit egress of the third satellite at 7h. 47m. P.M., and of its shadow at 9h. 5m. P.M. On the 29th an occultation disappearance of the second satellite at 0h. 2m. A.M.; its reappearance from eclipse at 2h. 50m. A.M.; a transit ingress of the first satellite at 3h. 2m. A.M., and of its shadow at 3h. 19m. A.M.; a transit egress of the satellite at 5h. 14m. A.M., and of its shadow at 5h. 31m. A.M. On the 30th an occultation disappearance of the first satellite at 0h. 13m. A.M., and its reappearance from eclipse at 2h. 40m. 45s. A.M.; a transit ingress of the second satellite at 6h. 25m. P.M.; of its shadow at 7h. 1m. P.M.; a transit egress of the satellite at 8h. 41m. P.M., and of its shadow at 9h. 22m. P.M.; a transit ingress of the first satellite at 9h. 28m. P.M., and of its shadow at 9h. 47m. P.M.; a transit egress of the satellite at 11h. 39m. P.M., and of its shadow at midnight. The following are the times of superior and inferior geocentric conjunctions of the fourth satellite with the centre of the planet:—Superior, November 7th, 11h. 42m. P.M., 24th, 1h. 44m. P.M.; Inferior, November 16th, 8h. 1m. A.M.

Saturn does not rise till 3h. 16m. A.M. on the last day of the month, and Uranus is in conjunction with the Sun on the 3rd.

Neptune is very well situated for observation, rising as he does on the 1st at 6h. 2m. P.M., with a northern declination of 20° 49′. On the 30th he rises at 4h. 5m. P.M., with a northern declination of 20° 43′, and an apparent diameter of 2·7″. During the month he pursues a short retrograde path in Taurus, in a region barren of conspicuous stars.

November is a very favourable month for shooting stars. The most marked displays are the Leonids, on November 13th and 14th, the radiant point being in R.A. 10h. 0m., and northern declination 23°. The radiant point rises at about 10h. 15m. P.M. The Andromedes occur on the 27th, the radiant point being in R.A. 1h. 40m., northern declination 43°.

The Moon is new at 0h. 57m. P.M. on the 8th; enters her first quarter at 5h. 45m. P.M. on the 16th; is full at 6h. 8m. P.M. on the 23rd; and enters her last quarter at 9h. 8m. A.M. on the 30th. She is in apogee at 4h. A.M. on the 12th (distance from the earth 252,330 miles); and in perigee at 2h. P.M. on the 24th (distance from the earth 222,310 miles).

Chess Column.

By C. D. Locock, B.A.Oxon.

ALL COMMUNICATIONS for this column should be addressed to the "CHESS EDITOR, *Knowledge Office*," and posted before the 12th of each month.

Solution of October Problem (G. K. Ansell):—

1. B to K2, and mates next move.

CORRECT SOLUTIONS received from Alpha, W. A. Champion, F. O. Lane, J. E. Gore, W. A. J. Pennett, H. S. Brandreth, W. Willby, A. E. Whitehouse, J. M'Robert, R. F. Arden, P. Henri, F. Glanville, and R. B. Cooke.

Humilis.—Pseudonym for Tourney duly recorded.

Alpha.—We shall regret the temporary loss of our most constant solver.

W. A. Champion.—Perfectly correct this time.

P. Edwards.—Mortimer's *Pocket Guide* is the best small book on the openings (price 1s.). If you require a larger book, we should advise either Gossip's *Theory of the Chess Openings*, or Freeborough and Ranken's *Chess Openings*. We believe that the new edition of the latter work contains a treatise on "Odds."

Crossgar.—The two-mover "Ballymore," has no apparent solution. On the other hand, "Wood Green" has at least *three*, if that is any compensation. The enclosure mentioned was omitted, but the problems shall be kept in case you want them again.

Posuit ultimum lapidem.—Tu quoque turriculo lapidem extremum posuisti.

"KNOWLEDGE" PROBLEM TOURNEY.

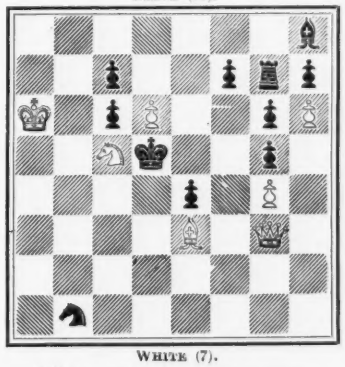
The following problems have been entered for this tourney:—"Sweetness and Purity, &c.," "Stella," "Bonne bouche," "Fortes fortuna juvat," "Cave coquum," "Pro virtute," "Lieblich sind überstandene Mühen," "Invicta," "Morceau," "Nulli secundus," "I can't help your troubles," "Slender," "East Harling," "A Norseman's a Chess-piece," "Enrichetta," "La Retraite," "The Circle," "Posuit ultimum lapidem."

Three other positions have been reluctantly excluded in accordance with Rule 5, and have been returned to their respective composers. The order of publication—a not unimportant matter where solvers take part in the judging—will be decided by ballot. Three problems, as a rule, will be published in each number.

POSITION No. 1.

"Pro virtute."

BLACK (11).



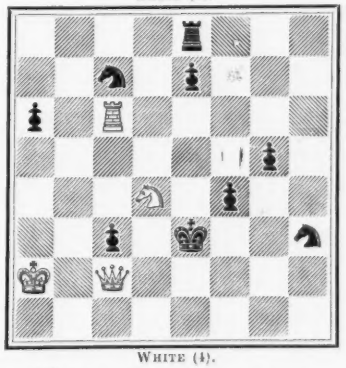
WHITE (7).

White mates in three moves.

POSITION No. 2.

"I can't help your troubles."

BLACK (9).



WHITE (4).

White mates in three moves.

SOLUTION TOURNEY.

Solutions, to be in time, must bear a post-mark not later than the 12th of the month in which the problems appear. They should be addressed to C. D. LOCOCK, Burwash, Sussex. Key-moves and dual continuations (if any) alone need be given. It will obviously be unfair to publish any criticisms of problems during the progress of the tourney, but the Chess-Editor will be interested to receive them.

Marks will be awarded as follows:—For each correct key-move, three points; for each dual continuation (on the second move), one point. One point will be *deducted* for every incorrect claim. If a problem has no solution, "No solution" must be claimed. If a problem has more than one solution, duals will not score. "Short mates" take precedence of all others.

Should any problem be incorrectly printed it will be cancelled and republished.

Information as to the correctness of any diagram cannot be given. All diagrams must be assumed to be correct unless the number of pieces on any diagram disagrees with the number stated. In that case no notice need be taken of it.

Those solvers who intend to qualify for the "Coroner's Jury" (*vide* Rule 7), by solving every problem correctly, are particularly requested to keep a record of their impressions of each problem as it is published. Merits or defects, clearly visible at the time, are otherwise liable to be forgotten after an interval of six months. This hint is, of course, only necessary in the case of our less experienced solvers.

The following prettily played game is taken from the *Liverpool Mercury*. It was played in a recent match between Liverpool and Dublin.

ZUKERTORT'S OPENING.

WHITE (A. Rutherford).	BLACK (A. S. Peake).
1. Kt to KB3	1. P to Q4
2. P to Q4	2. Kt to KB3
3. P to K3	3. P to K3
4. P to QB4	4. P × P
5. B × P	5. P to QB4
6. Castles	6. B to K2
7. B to Q2	7. Castles
8. B to B3	8. Kt to K5
9. Q to QB2	9. Kt × B
10. Kt × Kt	10. P to QR3
11. QR to Qsq	11. Q to B2
12. B to Q3	12. P to KR3
13. Kt to K4	13. Kt to Q2
14. P × P	14. P to KB4
15. Kt to Kt3	15. Q × P
16. B to B4	16. K to Rsq
17. Q to Kt3	17. Q to Kt3
18. Kt to K5 !	18. Q × Q
19. Kt to Kt6ch	19. K to Ktsq
20. B × Q	20. K to B2
21. Kt × BP	21. Kt to B4
22. Kt(B5) × B and wins	

CHESS INTELLIGENCE.

Mr. Lasker, after defeating Mr. Ettlinger of the Manhattan Chess Club by 5 games to 0, has entered for a tournament arranged in New York, for the benefit of those players who had intended to take part in the Columbian Chess Congress. The other competitors are M. Taubenhaus of Paris, Dr. Schmidt of Dresden, Herr Albin of Vienna, Messrs. Jasnogrodsky, Lee, and Gossip of London, and Messrs. Delmar, Pollock, Showalter, Pillsbury, Olly, Ryan, and Major Hanham of the United States. Mr. Lasker won his first three games in fine style, and should be certain of the first prize. Mr. Lee also made a good start. The performance of Mr. Pillsbury, the winner of a brilliant consultation game against Steinitz, published in this column a few months ago, will be watched with great interest.

A match by correspondence is announced between Mr. Steinitz and the Liverpool Chess Club. Two games will be played, the time limit being one move a week.

Mr. C. E. Biaggini, the hon. sec. of the North London Chess Club, informs us that the club has recently changed its quarters. It now meets at the Amhurst Club, Amhurst Road, N., on Thursdays at 7.30.

The *Hackney Mercury* announces its eleventh Problem Tourney, for two-move and three-move direct mates. Composers are limited to one problem in each section. Entries to be made before March 1st, 1894.

The announcement of the match now in progress at St. Petersburg between Dr. Tarrasch of Nuremberg, and M. Tschigorin of Russia, came as a surprise to most chess-players. The negotiations were conducted in secret and the match commenced without delay early last month. Dr. Tarrasch won the first game, a Ruy Lopez, with the greatest ease in twenty-nine moves, his opponent going all to pieces in the middle game. In the second game Tschigorin met the French Defence in the strangest fashion, and had to remain strictly on the defensive for some thirty moves, while the German master pressed the attack on the Queen's side with great skill, and eventually won a Pawn. Tschigorin then obtained a counter-attack on the King's side, which his opponent treated with greater contempt than it deserved, the result being that the Russian, playing with great ingenuity, and aided by his adversary's neglect, succeeded in forcing a mating position on the forty-second move. M. Tschigorin won the third game in sixty-two moves, and lost the fourth in the same number. Dr. Tarrasch also won the fifth game in twenty-six moves. Probably few expected the Russian player to win two out of the first three games; and though Dr. Tarrasch certainly threw away the second game by over-confidence, it looks as if the match may be closer than was expected. The present score is: Tarrasch, 4; Tschigorin, 2; Drawn, 0.

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